ENVIRONMENTAL QUARTERLY

October • 1961

The Recognized Journal of Environmental Simulation

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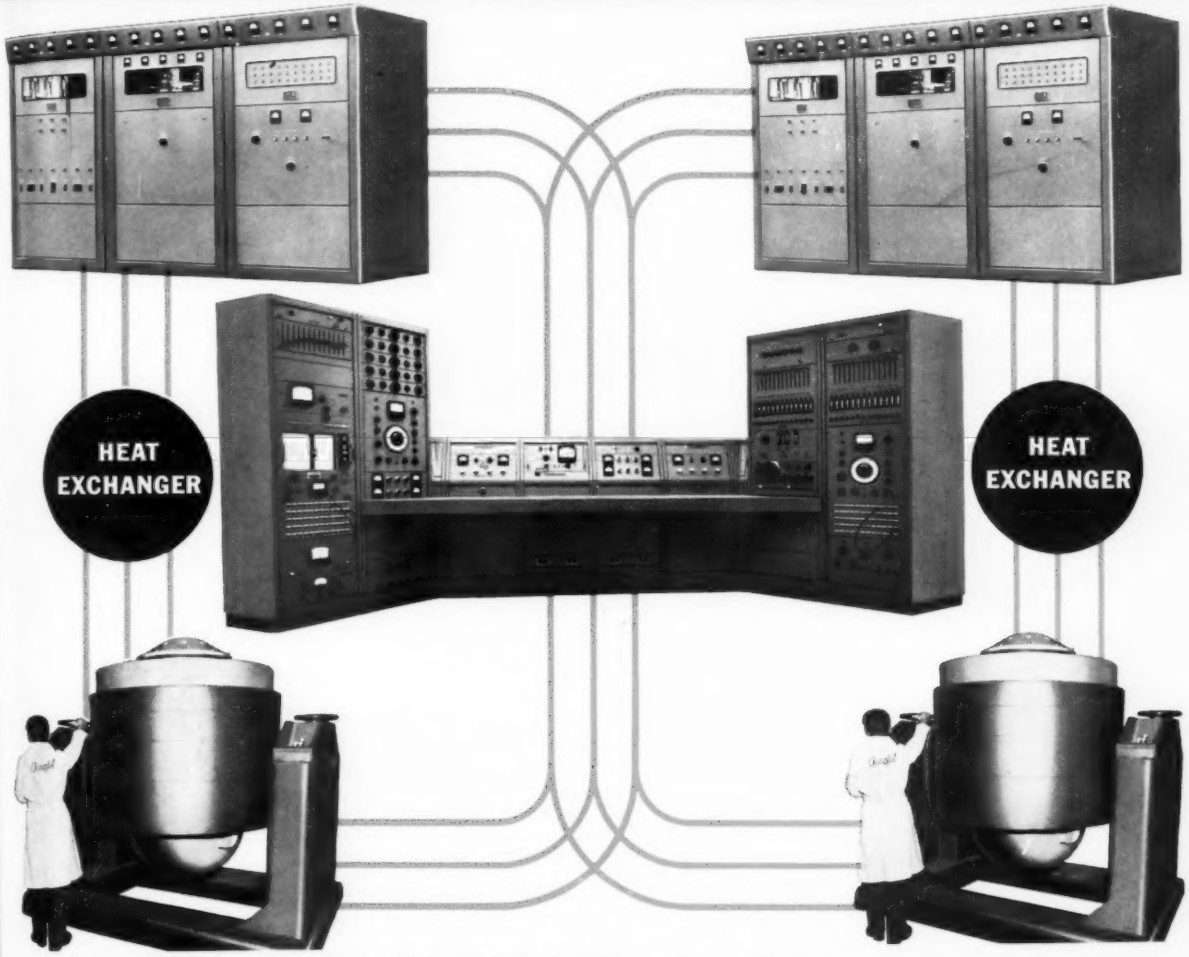
HIGHLIGHTS OF THIS ISSUE:

- *Space Torture*
- *V-Groove Sliding Table*
- *Vibration Seminar (II)*

INDEPENDENTLY PUBLISHED

Volume 7 • Number 4



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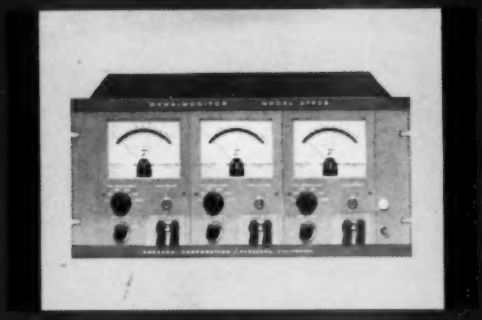

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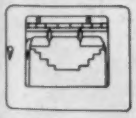
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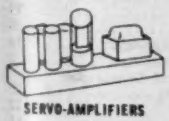
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ENVIRONMENTAL QUARTERLY

The Premier Space Age Publication of Environmental Simulation Testing, Engineering and Equipment Manufacturing

October • 1961 Volume 7 • Number 4

To Our Readers:

The next issue of *Environmental Quarterly* will reach you in early March, 1962, instead of January. The reason is that beginning next year we are going to publish on calendar quarters — March, June, September and December—instead of the January to October schedule as heretofore.

The issue you are now reading, therefore, is the last to be dated October, but there will be no break in volume and issue numbers. There will, of course, be four issues of *Environmental Quarterly* next year, as there were this year.

Of the many factors that prompted the change, the most important was the conviction that it would serve you better. The new schedule is more in tune with a number of events that play an important part in The Environment.

Your constant support of *Environmental Quarterly* is deeply appreciated. It has made possible our spectacular growth of the past few years and, we are sure, will provide the nourishment for future growth. We trust we will continue to merit it.

Martin Z. Post
Publisher

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Environmental Quarterly welcomes competent expressions of opinion, but statements in its pages do not necessarily reflect its views. Right is reserved to extract portions of letters and other material submitted for publication. Correspondents must identify themselves fully, but names will not be published if such a request is made.

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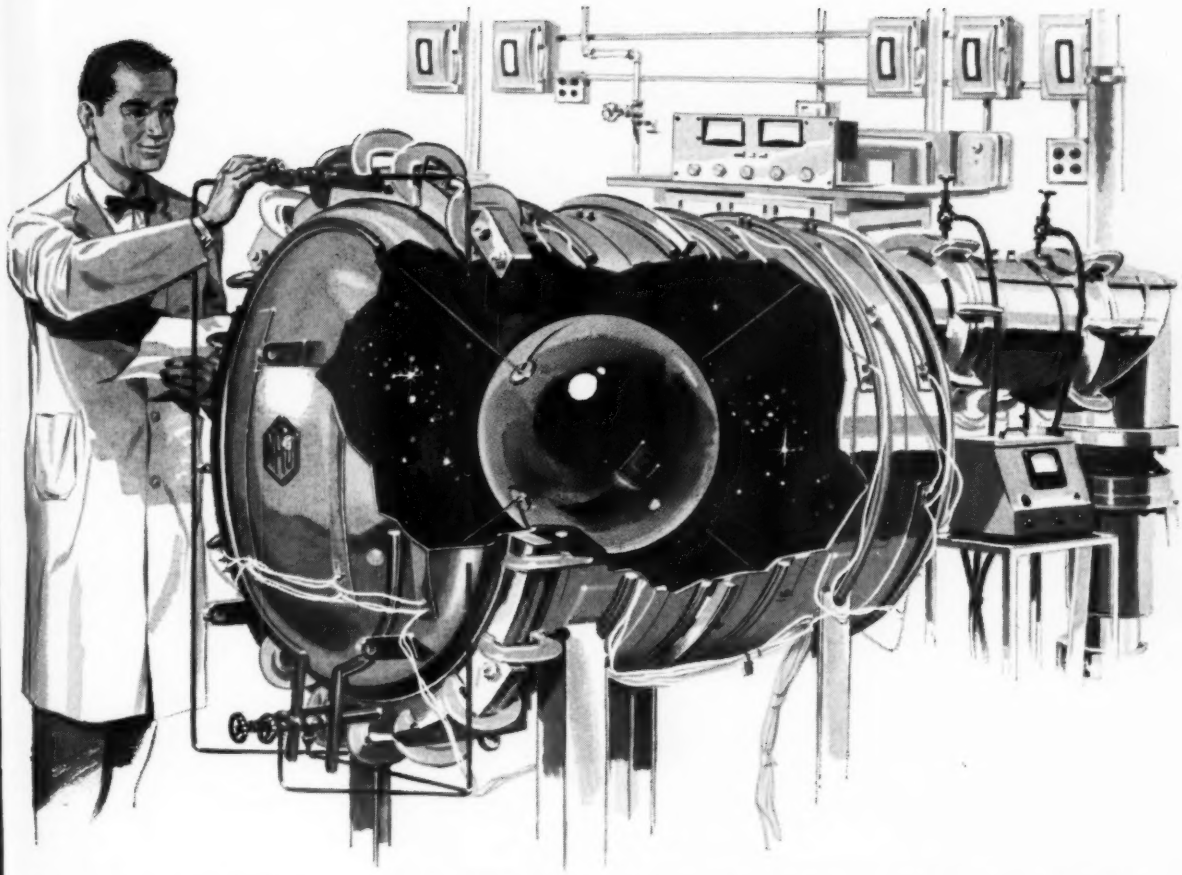

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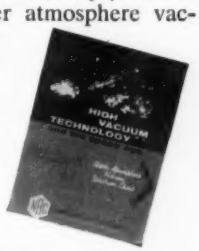


RESEARCH DIVISION
National Research NRC Corporation

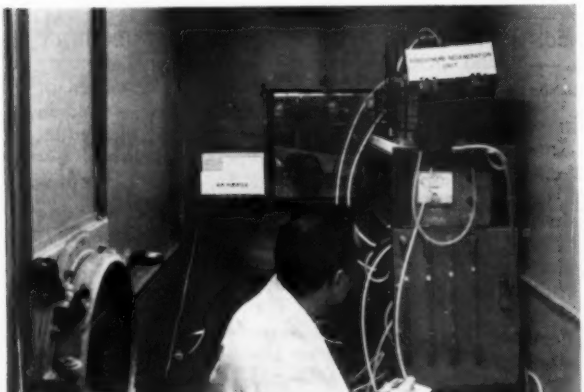
Environmental Quarterly's Album of People, Products, Places and Ideas...

ENVIRONMENTS ABROAD: Floor plans for Sud Aviation's new environmental test center in Cannes, France, are discussed (above, l. to r.) by Charles D. Brown, president of MB Electronics, and two of his international aides, Emil G. Oravec and Hans C. Christensen. MB is vibration equipment supplier for the new lab.

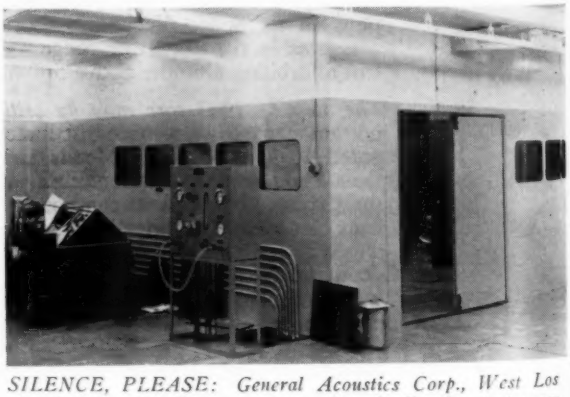
LOW PRESSURE: The Manufacturing division of Wyle Laboratories, El Segundo, Calif., puts finishing touches to ½-ton, portable, low pressure liquid CO_2 storage units built for Pure Carbonic Co. They will be used for a variety of environmental tests. (For more info circle EQ RSC "N.")

POLARIS PROFILE: Associated Testing Laboratories, Inc., Wayne, N. J., has received a new Polaris missile testing contract. Above, a "life profile" of Polaris components is being prepared with the use of digital automatic test equipment.

SELF-CONTAINED: Above is hydraulic test stand, Model HC20-5M, designed by Aerotest Laboratories, Inc., Deer Park, N. Y., to test and calibrate precision hydraulic items. The stand features a four-way selector valve for directional flow cycling and an accumulator to dampen line shock and pump pulsations. (For more info circle EQ RSC "O.")



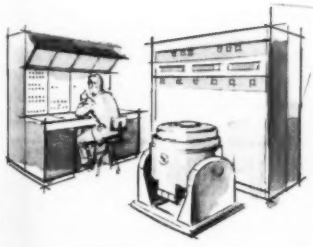
LIVING CONDITIONS: To design and test life support equipment, Ionics, Inc., Cambridge, Mass., has produced a 240-cubic foot environmental test chamber (above) that will swallow up researchers for days or weeks at a time. A device to recover oxygen and water will be the first test item.



SILENCE, PLEASE: General Acoustics Corp., West Los Angeles, has installed a new soundproof vibration test room (above) at Hughes' Aircraft's El Segundo Division. Made of prefabricated, modular sound panels, it is complete with doors and windows. (For more info circle EQ RSC "P.")

The important advances in environmental testing come from MB

New 5140MB power amplifier improves reliability in sine wave and complex motion testing



A pioneer and leader in the field of electrodynamic vibration systems, MB continually strives to improve the performance and reliability of vibration, shock and fatigue testing. The important advances in environmental testing come from MB.

MB Electronics has representatives in principal cities throughout the world.

The Model 5140MB Power Amplifier is designed to drive the Model (C210) 28,000 lb. force and Model (EL 10,000) 40,000 lb. force vibration exciters. Rated at 140,000 volt amperes output with plate dissipation of 240 kw, the amplifier offers the most conservative and reliable operation in the vibration testing field. It will readily handle all the adverse inductive and capacitive loading of the electrodynamic exciter.

These outstanding features are responsible for the greater reliability of the Model 5140MB amplifier:

1. 15 db negative feedback provides lowest source impedance and lowest distortion into the shaker load.
2. Oversized driver tubes for high random peaks.
3. Oversized amplifier with oversized output tubes.
4. Plate dissipation capabilities exceed vibration exciter requirements by a minimum of 33⅓%.
5. Compact water systems feature "water-miser" regulation of secondary water and a demineralizer insures low conductivity in primary coolant.

For additional information on the new 5140MB Power Amplifier, write for Bulletin 134.

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Post Scripts

Clusters of Environments

From a master builder of The Environment, Consolidated Vacuum Corporation's Ed Perkins, comes a warning, a plea and an unusual plan.

The warning: The space effort faces trouble, and small industry will be squeezed out of it for lack of sufficient ultra-high vacuum facilities.

The plea: It is time small industry got an even break in the space field.

The plan: Construction of cooperative-type, advanced environmental test centers, patterned after the wind tunnel installations, at strategic points around the country.

And Ed, in an exclusive interview with Environmental Quarterly, made a pledge, too.

"CVC stands ready," he said, "to back up such an effort, whether under the auspices of NASA, the Air Force, or whoever will sponsor it.

"We will, with the proper sanctioning, set up and run an environmental test facility in any location that is properly oriented to industries of all sizes."

A Doer, Too

Ed knows something about the subject. As director of custom products for CVC, he is the man who designed two of the big simulators springing up throughout The Enviroment, JPL's and Lockheed's.

He has no doubt that these "captive" labs will leap-frog the state of the art, but therein lies a potential source of trouble. As each brings its prowess to bear on existing specs and surpasses them, tremendous pressure will build up to make the specs ever more stringent. Utmost reliability demands no less, but each advance will put test facilities a little more out of the reach of smaller firms. They simply can't afford them.

Neither can the ordinary commercial test labs. We're talking about facilities costing millions.

Edward W. Perkins
Advocates Co-Op Facilities

Won't outsiders be able to buy time in the simulators that are being built? Theoretically yes, practically no. Even before completion these facilities are being programmed to the hilt and booked for years in advance.

Highlights of the Plan

Ed's comments were made in New York in the midst of the gigantic space show, held at the Coliseum.

"Every manufacturer who wants space age business must have an environmental simulator to run reliability tests," he said. "Without it he's lost. Uncle Sam has to start thinking about co-op facilities around the nation."

Ed's plan envisions clusters of environmental facilities in which smaller manufacturers would be guaranteed time. Initially one cluster would serve New England, another the New York City area, a third Georgia-Florida, one the Midwest, another the Southwest and one or two the Far West—half a dozen all told as a start.

By cluster, Ed explained, he means a major chamber, perhaps 20 feet in diameter and 50 feet high, supported by several chambers of more modest size, say 10 x 20 feet, and other environmental equipment, shakers, shock machines, etc. As for performance, "we'd like to shoot for 10^{-10}," he said, adding: "I feel we can consistently modify these facilities to reflect the state-of-the-art."

Horizons Unlimited

The cost? Perhaps $5-$7 million per cluster to start. It would be recovered from contractual payments for time and "by improved reliability that would eliminate failures."

"We're still playing with a very narrow band of simulation," Ed said. "It is going to get wider—the horizons for environmental testing today are unlimited.

"We don't have to go all-out on the large jobs, but what we do need is to make the highest altitudes available to the smallest fellow for his parts testing, and then have something big enough to handle those parts when they go into sub-assemblies and assemblies. For every whole-missile facility that will be built in the future, we'll see maybe ten for components. But build them we must."

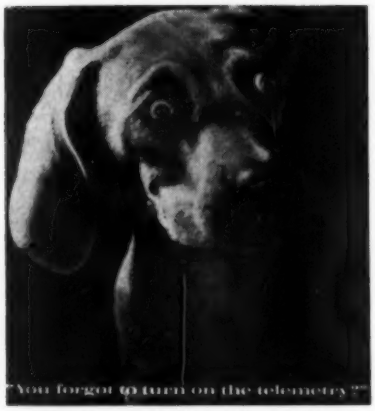
Some Problems

Areas in which considerable work remains to be done under high vacuum were listed by Ed as acoustic, thermal, vibration, sublimation, mechanical (bearings and lubrication) and energy conversion. Cold welding is still another major thermodynamic problem.

Ed has been with CVC for nearly a decade—the decade in which The Environment came into its own. When CVC set up its Custom Products department a year and a half ago to handle prime and sub-contract work in the design, development, engineering and manufacture of special systems involving vacuum technology, he was appointed its director, reporting directly to Frank M. Jenner, president of the company.

Ed attended Siena College and Niagara University and won his degree in mechanical engineering from Rensselaer Poly. During World War II, he was a Navy pilot in the Pacific, and subsequently was with a consulting engineering firm and with The Elliott Co., turbine-generator set manufacturer, before joining CVC. He holds a number of patents on high vacuum devices.

Words Without Music



Courtesy of Endevco Corporation

Time to Think It Over

Maybe, suggests the Air Force, the accepted eight hours on and 16 off isn't the best way of working in an around-the-clock operation. A special study by a couple of Lockheed men for WAAD indicates that two-on-two-off or four-on-four-off results in "a more favorable adjustment."

What's in a Paint?

Equipment enamel, says Labline, Inc., of Chicago, should be distinctive and crisp, scratch and flex-proof and have long life and eye-appeal.

It attributes these qualities to "Dura-Flex," chosen over 38 other paints, for its line of lab instruments and Hudson Bay Co. environmental test equipment.

The new paint is described as "an eye-pleasing, multi-color grayed blue" that goes well with any standard lab color.

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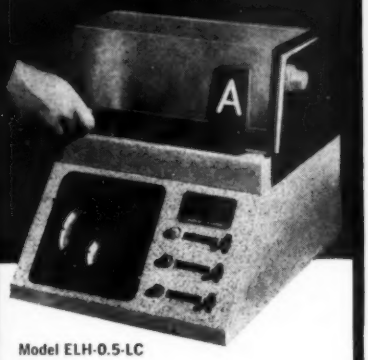

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Deflector Design Can Raise As Well as Lower Noise

An Air Force study of rocket engine noise indicates that deflector design can cause increases of more than 10 decibels as well as decreases of up to eight decibels. The study consisted of tests of standard 1,000-pound thrust JATO rockets and six scaled models of typical blast deflectors.

The Air Force found that conical, flat plate and curved plate deflectors produced considerable diffusion and diverted the exhaust flow, decreasing overall acoustic power level up to eight decibels.

Certain deflector designs were found, however, to cause increases of more than 10 db in the average near field sound pressure levels in regions where the missile structure would be located. Deflectors can significantly influence total output and spatial distribution of acoustic power produced by rocket engine operations, it was concluded.

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AROUND THE ENVIRONS...

Environmental Lectures Listed In East and West

The Fall's return-to-the-campus saw a back-to-school movement in environmental engineering, too.

In New York, the Institute of Environmental Sciences' New York Metropolitan chapter has joined with New York University in a 10-part series on "Shock, Vibration and Acoustic Noise." The first was held Oct. 3, with the others scheduled for successive Tuesday nights at NYU's College of Engineering.

Jesse Markson, chairman of the chapter's educational committee, is coordinator for the series, as he was for two previous courses sponsored by the chapter at Hofstra College in 1958 and Fairleigh-Dickinson University in 1959.

16 Lectures on Coast

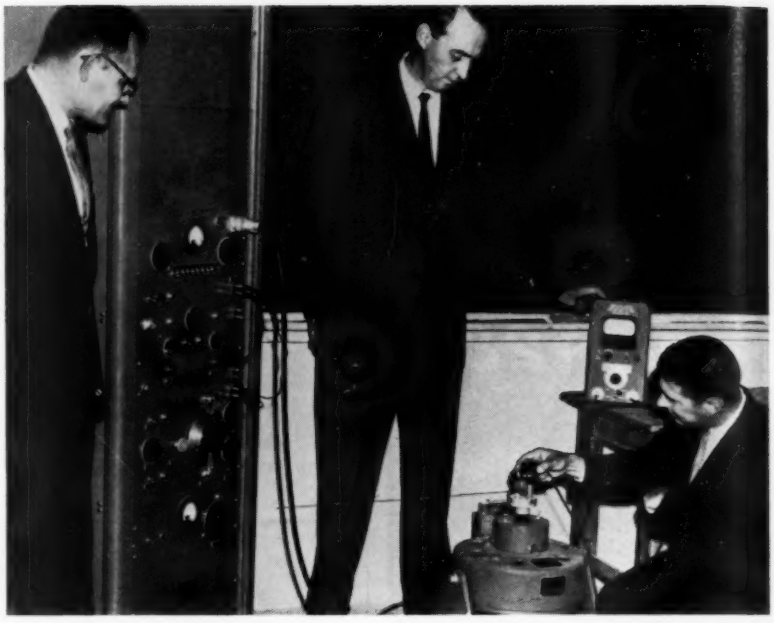
On the West Coast, the University of California opened a 16-lecture series on "Environmental Engineering" in Palo Alto and Sacramento. Topics listed ranged from the relation of environmental testing to the reliability program, to vibration, shock and acoustics, vacuum technology, cryogenics and test management.

John D. Campbell, of Philco, Palo Alto, is program coordinator.

Meanwhile, workshops concentrating on specific aspects of environmental testing are being scheduled throughout New Mexico as a result of a prototype conference conducted by Sandia Corporation in Albuquerque, Sept. 14 and 15.

More than 200 persons attended the initial session. Papers covered a broad spectrum of environmental interest, from philosophy and economics to space problems.

Fair Shaking on the Campus



The spread of interest in environmental engineering on the college campus has been abetted by gifts from equipment manufacturers.

Above, from the left, Dr. C. R. Freberg, head of the mechanical engineering department, University of Southern California; Dr. A. C. Ingersoll, USC's engineering dean, and Dennis Lynch, of MB Electronics, inspect one of three vibration test systems MB has donated to higher learning. The other two are at Yale and Brooklyn Polytechnic Institute.

Says MB's president, Charles D. Brown:

"The increasing emphasis in engineering colleges on vibration and other facets of environmental testing has added a new depth to current programs and has created a solid foundation for more and better education in the field.

"The combined result of the various educating influences at work in the environmental test field should be a significant increase in the effectiveness and economy of environmental testing."

Terminations Guidebook

A guide book to assist in settling contract terminations is being prepared by the Military Relations department of the Electronic Industries Association. It is expected to be particularly useful to small companies.

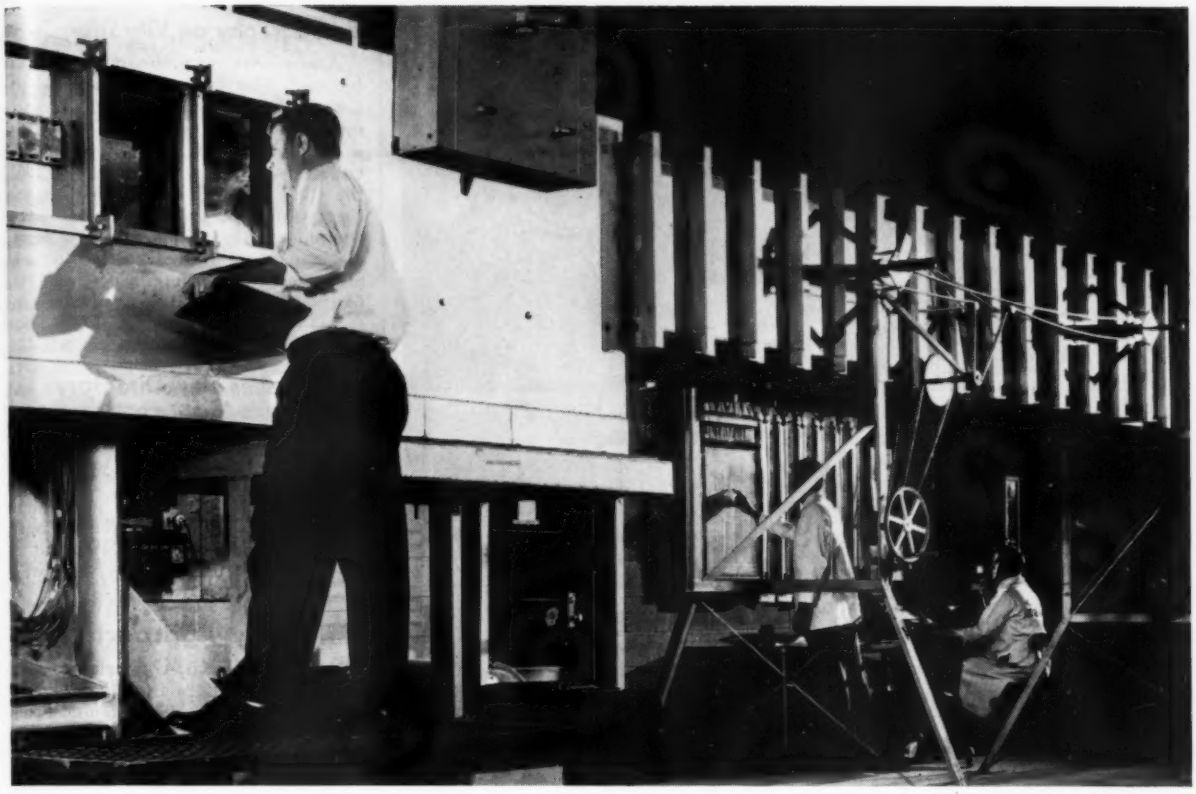
NEW MEXICO WORKSHOP on environmental testing was addressed by Dr. C Irwin Vigness (left), supervisory physicist and head of shock and vibration branch of the Naval Research Laboratory, Washington, D. C. Chatting with him are W. A. Gardner, director of environmental testing, and R. W. Henderson, vice president, weapons program, both of Sandia Corporation, which conducted the workshop.

Christensen, Ponge Named IES Fellows

Mark S. Christensen and Norman A. Ponge, veterans of The Environment, have been named fellows of the Institute of Environmental Sciences. The honors were awarded by the IES' national executive committee.

Christensen, currently fiscal vice president of the organization, has spent the past decade in various phases of environmental testing. He is now with Aerojet General, Azuza, Calif. His B.S.M.E. is from the University of Illinois.

Ponge formed Space-Tronics, Inc., a manufacturer's representative, in 1959 after more than a dozen years in charge of testing laboratories. He is past chairman of the New York Metropolitan chapter of IES and is exhibit chairman of the annual IES-sponsored trade show. His education was at Brooklyn Poly, Queens College and other schools.



Photo—Courtesy Cook Technological Center, Cook Electric Company.

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Whether you are testing sub-miniature components or giant aircraft and missile assemblies, a CARDOX liquid CO_2 cooling system can save you time, trouble, and expense. First, direct discharge of pure, clean CARDOX liquid CO_2 provides instantaneous cooling down to −110°F. There is never a delay with CARDOX CO_2 . . . you make more tests per hour, more tests per day.

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If you are planning new test equipment or modifying existing facilities, it will pay you to call your Cardox representative. For further information, write for Bulletin C7 K105. CARDOX, Division of Chemetron Corporation, 840 N. Michigan Avenue, Chicago 11, Illinois.

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'CompuDyne in Industry Fellowship' Awarded

A $1,000 check, representing the CompuDyne Foundation in Industry scholarship, is awarded to Dr. Gerald Weiss, assistant professor of electrical engineering at Polytechnic Institute of Brooklyn, by Dr. Melville Stein (left), president of Leeds & Northrup Company. Dr. Weiss was selected for the award by the Foundation for Instrumentation, Education and Research, Inc., for his work on hydraulic servos. G. Richard Archer, general manager of CompuDyne's Process Control division, looks on.

IES Accepting Papers

Notices of acceptance or rejection are going out from the IES technical program committee to those who submitted abstracts for papers proposed for the annual meeting next April. According to Frank P. Merry, chairman of the committee, accepted papers must be submitted by Jan. 15, together with biography and photo of the author.

Standards Committee Meets

The committee organized last year to work on a glossary of environmental terms scheduled a meeting Oct. 19 at the American Standards Association headquarters in New York. Twenty-four societies and representatives of government agencies were to participate under Roger J. Amorosi, chairman, representing the IES.

Government Publishes New Bibliography on Vibration

A new selective bibliography on "Vibration" has been published by the Office of Technical Services, Department of Commerce.

Listing material added to the OTS collection between 1950 and July, 1961, the bibliography covers vibration theory, analysis and measurement; test equipment, damping and isolators; mechanical vibration, vibration in metallurgy, and the physiological effects of vibration. It is available from the OTS (Washington 25, D. C.) for 10 cents. The order number is SB-436.

ACIL Issues New Directory

The American Council of Independent Laboratories, Inc., has issued the eighth edition of its directory, cross-referenced to provide an at-a-glance listing of all laboratories performing certain tests. Copies may be obtained by writing on company letterhead to the ACIL at 4302 East-West Highway, Washington 14, D. C.

A Nerve-y Approach?

Lt. Gen. Bernard A. Schriever, chief of Air Force R & D, suggests that space vehicle electronic systems be patterned after living organisms. Living mechanisms function despite partial damage to nerve systems, he points out, whereas malfunctioning of a single missile part causes total failure.

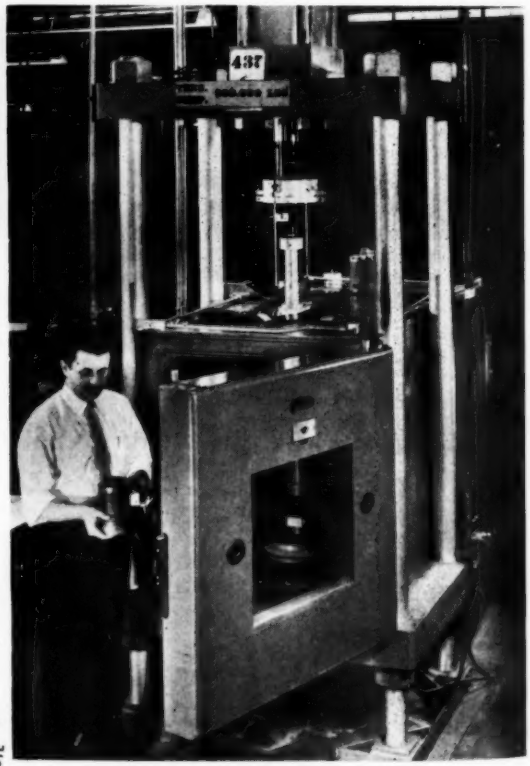
BALDWIN BLH LIMA-HAMILTON

BALDWIN-LIMA-HAMILTON RELIES ON HARRIS CASCADE REFRIGERATION FOR CALIBRATION AND ENVIRONMENTAL TESTING OF TRANSDUCERS (-100° F. TO +200° F.)

Baldwin-Lima-Hamilton Corporation, E and I Division, Waltham, Mass., has had "excellent" service from their Harris 38LE-U2-20 Environmental Test Chamber, according to G. Lauderdale, their Manager of Sales Administration.

They use the unit "for calibration and precision transducers, also for environmental testing of transducers and checking for modulus of elasticity in our precision-machined and assembled electro-mechanical devices."

Mr. Lauderdale further commends their Harris equipment as "excellent in our applications, providing accuracy of temperature control over our temperature span of —100° F. to +200° F."



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Research and Study Awards Announced

Ling - Temco - Vought, Inc., Dallas, Texas has been awarded two contracts by NASA's Marshall Space Flight Center for environmental studies of the Saturn space vehicle. Total value of the contracts is more than $81,000.

One, for $73,900, covers tests of instrumentation under simulated conditions of shock, acceleration, temperature, altitude, vibration and radio interference, among others. The other involves vehicle vibration analysis by means of an IBM 704 computer.

Three Air Force contracts and a NASA contract have been awarded to **National Research Corporation,** Cambridge, Mass., for space vehicle research and development.

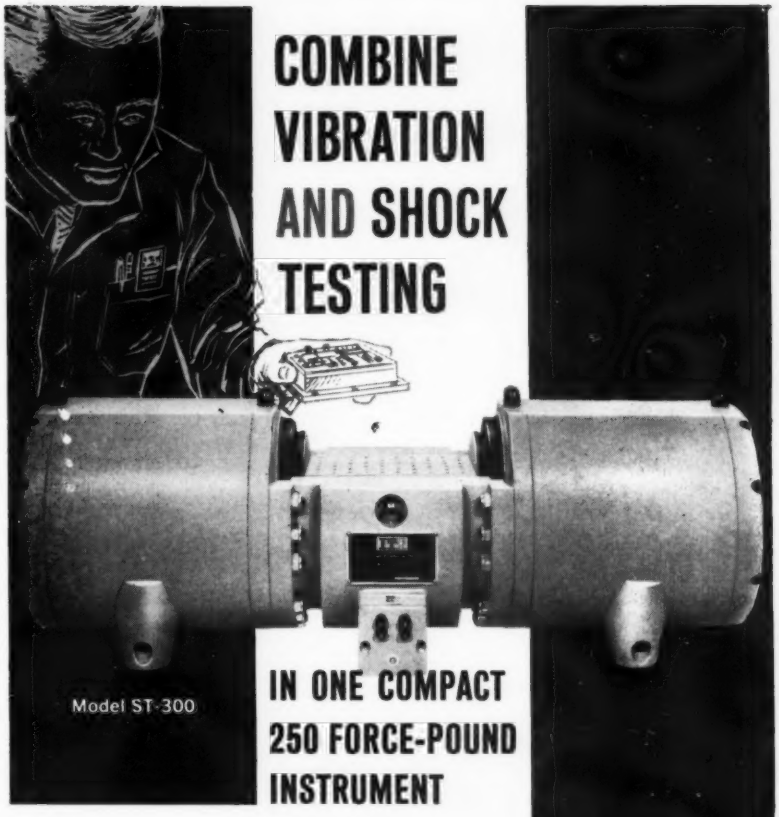
An AF contract for $250,000 extends to a third year NRC work on encapsulated ingredients for solid propellants. Another, from the Arnold center, continues research on ultraviolet radiation effects at an altitude of 600 miles, particularly radiation in the 1150 Angstrom range. Development of a solar energy converter is the subject of a $79,800 extension contract from the Aeronautical Systems Division, Wright-Patterson AFB, Ohio, while the properties of cesium, a promising ion-engine fuel, and systems for feeding this material into ion-engines will be investigated in a preliminary study sponsored by NASA's Marshall Space Flight Center.

Genarco Inc., Jamaica, N. Y., has been awarded a research contract by NASA, Lewis Research Center, for a 400-ampere high intensity carbon arc lamp to be used as a source of radiation in a solar radiation simulator. The arc lamp was scheduled for operation this Fall.

Genisco, Inc., Los Angeles, has received two contracts from the Air Force, one for the development of an ultra precise centrifuge that Genisco expects to become the master centrifuge for use in the calibration of inertial guidance components, the other for ground support test equipment for the H-34B Helicopter. Dollar amounts were not disclosed. Genisco also announced a feasibility contract from Sandia Corp. for the development of special centrifuge applications.

Cryo-Therm, Inc., of Fogelsville, Pa. has been awarded a contract by the Lockheed Missile and Space Corporation for Transit Heet temperature stabilization systems for shipping Polaris missile guidance capsules, John D. Wilson, vice president of Cryo-Therm, announced. Value of the completed containers will approximate one million dollars.

Awards for Transit Heet shipping containers for gyroscopes and guidance system components had previously been received from Sperry Gyroscope, A. C. Spark Plug, Massachusetts Institute of Technology, General Electric Co. and the Navy.



COMBINE VIBRATION AND SHOCK TESTING IN ONE COMPACT 250 FORCE-POUND INSTRUMENT

FOR LARGE COMPONENTS AND SMALL SUBSYSTEMS . . . the new ITT ST-300 offers a 250 force-pound exciter for vibration *and* shock testing. This latest in a series of dynamic new vibration equipment utilizes the unique concepts of lateral motion excitation and air-bearing support—both developed by ITT engineering and proved on ITT's other vibration exciters of the 100 and 200 Series.

The exceptionally flat frequency response of the ST-300 permits precise testing without the need for elaborate compensating devices. Natural resonances are unaffected by table loadings. In addition, by checking shock *and* vibration on the same instrument, testing time and cost are substantially reduced. Other significant features of the ST-300 include:

- *no significant distortion throughout normal test range*
- *first major resonance above 5 Kc*
- *useful frequency from 5 cycles to 50 Kc*
- *shock testing to over 5,000 g's*
- *table size: 5" x 8"*

For complete information and applications data, call an ITT Instruments representative or write for Data File EQ-1426-1.

Other ITT vibration exciters include:

ST-150 for testing one ounce loads to over 100 g's

ST-100 for small component production testing and accelerometer calibration

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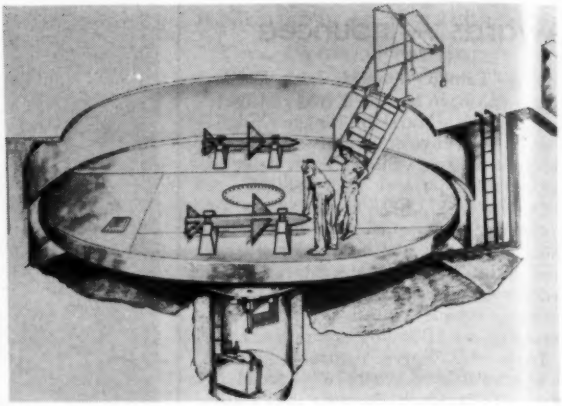


Drawing of disc-type centrifuge The Rucker Company is placing under ground at Pt. Mugu, Calif., shows missiles in test position. It is also rated at 50,000 g-pounds.

Path of the Environment:

ONWARD, UPWARD, AROUND

In "High, Wide and Spatial" (July, 1961) **Environmental Quarterly** presented a review of some of the exotic simulators built or a-building in "the biggest roll-back of environmental frontiers" in history. Here are other examples to prove the point.

Another for Long Island: CB&I Builds for Grumman

A second major space simulator is growing on Long Island, where Republic Aviation last April dedicated a 150-mile "space ship." By the end of the year, Chicago Bridge and Iron Company is scheduled to turn over to Republic's neighbor, Grumman Aircraft Engineering Corp., of Bethpage, an "earth space station." It will be used initially to test a full-scale prototype of the orbiting astronomical observatory Grumman is developing for NASA.

The Grumman simulator, too, will simulate 150-mile altitudes, producing temperatures of —320° to +350°F. The chamber will measure 19 feet across and 28 feet from the ground up.

A combination of diffusion pumps, blowers and rotary gas ballast pumps will provide vacuum in the 10^{-7} mm Hg range. With a liquid nitrogen shroud to simulate black space, the cryogenic system will include a vaporizer and a heat exchanger for quick heat-up in an emergency.

Giant Centrifuges: G + Environments

Two giant centrifuges are on order for installations clear across the country.

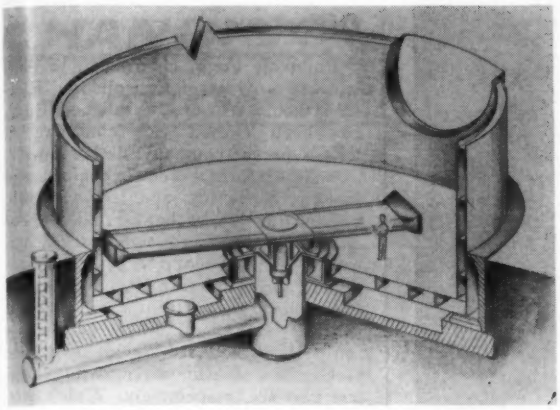
Trio Tech Company, Burbank, Calif., has been selected to design and build a 50,000 g-pound facility for NASA's Langley Research Center. It will be used for various programs, including Project Apollo, the moon shot.

A centrifuge of the same rating is being designed for the Naval Missile Center at Pt. Mugu, Calif., by The Rucker Company, Oakland, Calif.

R. K. Schwartz, Trio-Tech's chief engineer, said the NASA contract calls for an off-set radius arm that will swing in an arc with a 41-foot diameter. It will operate in a giant, 50-foot various chamber, carrying a 500-pound test object to 100 gs, or 50,000 g-pounds, and a 2,000-pound object to 25 gs.

The vacuum chamber will simulate 200,000 feet for acceleration tests, and be capable of still lower pressures. Seals between the powerhead and rotor hub will permit the reduced atmosphere of 200 microns Hg absolute. For further evacuation to 1×10^{-4} mm Hg absolute, or some 350,000 feet, a static seal will be placed between the top of the power spindle and the arm to prevent measurable leakage past the static seal.

Speed of the rotor will be infinitely adjustable. Electric power will be furnished the items under test through slip ring assemblies requiring 120 circuits. A hydraulic gland assembly, containing two ports with ¾-inch lines



Giant centrifuge-within-a-vacuum-chamber being built for Langley Research Center by Trio Tech Company. It will carry 500 pounds to 100 gs under high altitude conditions.

and operating up to 3,000 psi, will transmit hydraulic fluids through the power spindle to test packages at either end of the arm.

32-Foot Diameter Disc

A disc 32 feet in diameter is the feature of the ultra centrifuge of the Rucker project.

The huge system will test missile components, sub-assemblies and electronic systems at all g forces found in actual flight. Rated at 50,000 g pounds acting 24 inches above the top of the disc, it will take concentrated package loads of up to 5,000 pounds and will be equipped with a 5,000-pound counterbalance. Maximum acceleration will be 100 g.

Power will be supplied by a hydraulic, infinitely variable speed drive system. The centrifuge will have a rotary coaxial transfer ring, six rotary fluid couplings and 100 electrical slip rings.

Decompression Unit for Boeing Bio-Astronautics

A high altitude chamber with explosive decompression features to simulate puncturing of a space vehicle by a meteorite is being built for Boeing Airplane Company's Bio-astronautics section by Vacudyne Corporation, Chicago.

Arthur N. Lederman, president of Vacudyne, said the chamber will make it possible, for the first time in a common lab facility, to reach 200,000 feet of altitude or 250 feet below sea level in only 15 minutes.

The chamber's main compartment will be 10′ x 8′ x 22′, permitting 10 men to enter simultaneously. There will be an 8′ x 6′ lock for observers, and a chamber of the same size for decompression.

The chamber will withstand temperatures from —40° to +220°F, and will simulate various humidities.

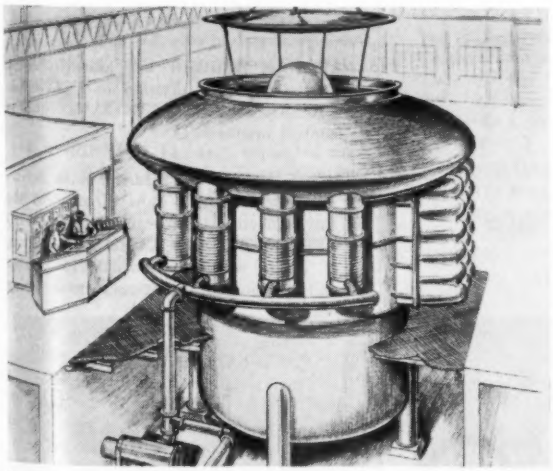
Vacudyne designed the rapid decompression valve that will allow control of both equalization pressure and time of decompression from rapid to explosive in microseconds.

Breakthrough Claimed By Ilikon—1,000 Miles

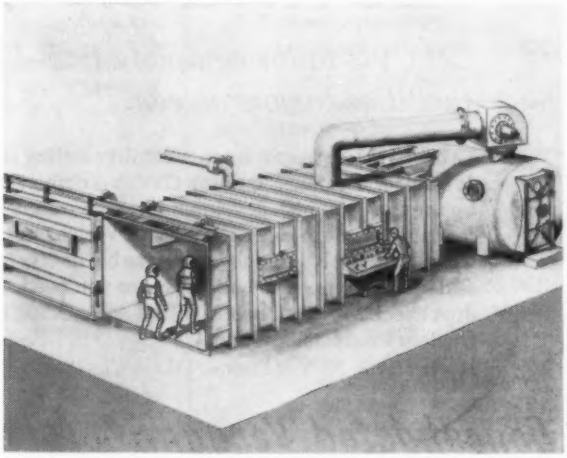
Ilikon Corporation, Natick, Mass., claims to have developed a chamber capable of simulating the atmosphere at 1,000 miles, with thermal and ultraviolet radiation. The temperature range is —300° to +4,500°F.

Neil Rogen, president of Ilikon, said the altitude represents a "breakthrough" in space simulators. He credited Imre Farkass, Ilikon's director of applied physics, with the design.

Size details were not given in the announcement, which said the simulator will permit introduction of both high and low-speed motion. It is being made available on a service basis.



Earth space station is being built by Chicago Bridge & Iron Company for Long Island's Grumman Aircraft. It will simulate 150 miles of altitude and —320° to +350° F.



For astronaut training and equipment testing, Boeing's Bio-Astronautics section has ordered this explosive decompression chamber from Vacudyne Corp.

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Companies Name Directors

Philip S. Fogg, chairman and chief executive officer of Consolidated Electrodynamics Corp., Pasadena, Calif., has been elected vice chairman of CEC's parent company, Bell & Howell. . . . William M. Wetzel, chairman of the Fyr-Fyter Co., and Henry Dolch, a Newark, N. J., banker, have been elected to the board of Tenney Engineering, Inc., Union, N. J. . . . Directors of Wyle Laboratories, El Segundo, Calif., have elected four new members to their board: Prof. Harold E. Edgerton, of MIT, Richard W. Jones, Robert J. Garon and Elmer R. Easton. The last two are, respectively, Wyle's vice president and general manager and vice president, field engineering and contracts.

MAURICE L. TORTI has been promoted to director of metallurgical research for the Metals division of NATIONAL RESEARCH CORP., Cambridge, Mass. Dr. Torti joined NRC in 1956.

* * *

EDWARD J. HORKEY, a founder of HORKEY-MOORE ASSOCIATES, is planning to organize a new engineering firm in the aerospace field. Prior to founding Horkey-Moore, he was with Pastushin Aviation Corp. and North American Aviation.

* * *

NICHOLAS J. GUARINO has joined the Space Instrumentation division of TECHNOLOGY INSTRUMENT CORP. OF ACTON, Acton, Mass., as aero-mechanical engineer. He was formerly with the Air Force Cambridge Research Laboratory and with the propulsion and the propeller laboratories at Wright Field.

* * *

HARRY D. DICKINSON has been named western district sales manager for GULTON INDUSTRIES, Metuchen, N. J., with offices in Hawthorne, Calif. He was formerly with Litton Industries, Wallace O. Leonard Co. and G. M. Giannini and Co.

* * *

ABRAHAM OSBORN has joined the St. Petersburg, Fla., division of INTERNATIONAL RESISTANCE CO. as quality control manager.

* * *

PAUL F. WAIVERS, formerly with Schaevitz Engineering, is now director of the Environmental Devices division, UNITED AERO PRODUCTS CORP., Burlington, N. J. He will be responsible for design and development of environmental testing devices.

* * *

LEO S. PACKER has been named manager of the military Products division of BAUSCH & LOMB INCORPORATED, Rochester, N. Y. Dr. Packer, who had been the division's chief engineer, succeeds **WILLIAM A. KERR,** now president of B&L's subsidiary, Applied Research Laboratories, Inc., Glendale, Calif.

People You Know...

CHANGING ENVIRONMENTS

Ross

Diesel

Wilner

McGinnis

FRANCIS L. ROSS has been named sales manager of the Micromodular Components division of LING-TEMCO-VOUGHT, INC. The division specializes in encapsulated welded modules, including high voltage rectifiers, and environmental qualification testing. Ross, formerly with Sylvania Electric and Hughes Aircraft, is a UCLA graduate.

* * *

JERRY P. ROSENBLATT, who had been with International Radiant Corporation, has joined the Environmental Engineering division of the BETHLEHEM CORPORATION in a staff position.

* * *

L. BRUCE WILNER and **T. J. DIESEL,** have been appointed project scientists at ENDEVCO CORPORATION's new Solid State Laboratory at Los Altos, Calif. Wilner, a magna cum laude Yale engineer, got his master's at Stamford. He came to Endevco via the Los Almos Scientific Laboratory and Lockheed's MSD, where Diesel also worked. Diesel, a University of Colorado physicist, holds patents in the field of piezoelectricity.

* * *

MARK A. McGINNIS has been promoted from sales manager to vice president-sales of THE SINGLETON COMPANY, Cleveland manufacturer of corrosion test cabinets. He will also be responsible for advertising and for an expanding distribution program on the North American continent and overseas.

* * *

J. B. O'CONNELL has been appointed consulting field engineer for Barry Controls division, BARRY WRIGHT CORPORATION, with offices in Montreal. He was sales engineer with Samuel C. Hooker (Canada) Ltd.

LEE N. MORTENSON has been appointed manager of the research and analysis department of WYLE LABORATORIES, El Segundo, Calif. While responsible for all advanced development programs, he will continue as manager of Air Force Ballistics Systems division program at Wyle. He is a UCLA graduate and a registered professional engineer in California, and a member of ARS, ASTM and Tau Beta Pi.

* * *

JOHN F. TIERNEY, JR. has been promoted to regional sales manager of PURE CARBONIC COMPANY, division of Air Reduction Company, Inc., with responsibility for Pureco sales in Calif., Wash., Ore., Nev., Ariz., Idaho, Mont., Wyo. and Utah. He was formerly a Pureco sales representative.

* * *

RICHARD F. WENKE has joined TENNEY ENGINEERING, INC., Union, N. J., as development engineer. A member of IES, he previously was a liaison engineer with International Radiant Corp.

* * *

PAUL GOTTFRIED is now with BOOZ, ALLEN APPLIED RESEARCH, INC. as a reliability scientist in the Washington, D. C. offices. He was previously a partner in Reliability Engineering Associates, Chicago, and earlier was associated with Cook Electric Co., Chicago Aerial Industries, Chambers Corp. and Charles N. Debes & Associates. He is a member of the IES.

* * *

A. E. CREEK has been appointed engineering liaison and sales rep in the Washington-Oregon area for WYLE LABORATORIES.

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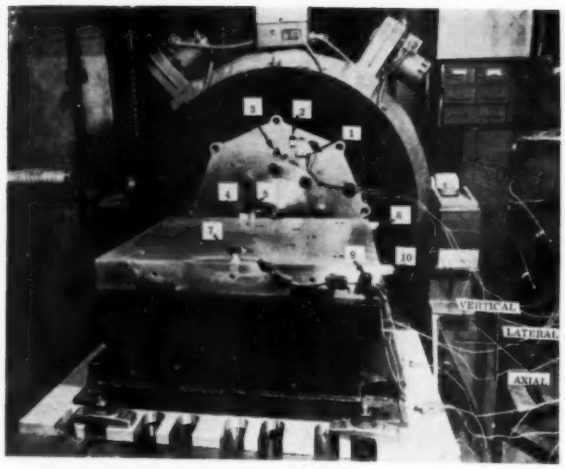


Figure 1
End view of V-groove table

by Daniel Stern
Vibration and Stress Analysis Engineer
LMED, General Electric Company

V-GROOVE FOR AN OIL FILM VIBRATION TABLE

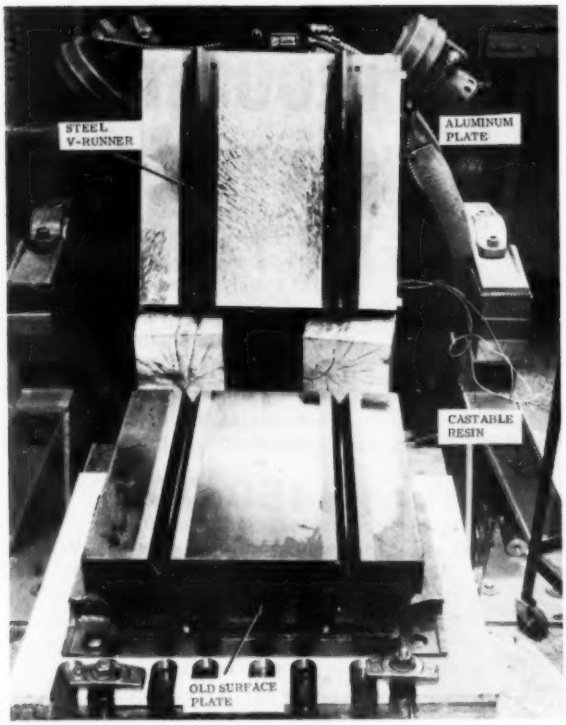


Figure 2
V-groove details

WE HAD BEEN CONDUCTING horizontal vibration tests on an oil film table driven by an electrodynamic vibrator. When the table was driven axially, the oil film offered an appreciable amount of resistance to vertical motion, although there was no appreciable resistance to lateral motion.

The reduction of cross-talk and of spurious lateral and vertical motion was desirable to maintain high accuracy in vibration tests on inertial equipment. There was also some difficulty in maintaining the finish of the mating surfaces. Quite often, the stone and the plate had to be hand scraped to remove abraided areas.

It was felt that the oil film table had lateral motion because the moving element was not restricted in the lateral direction, and so side guides were tried. However, because there had to be some clearance between the moving element and the side guides to keep friction force in the drive direction to a minimum (a 10 g vector sinusoid at 443 cps has a peak-to-peak displacement of 0.001 inch) side guides were considered not effective.

A reasonable approach for reducing lateral motion seemed to be to offer the moving element a well-defined path, such as a V-groove. The groove would not reduce the effective oil film area appreciably, so that the vertical constraint offered by the oil film would not be reduced. A V-groove, it seemed, would also solve the problem of force-lubricating a flat surface by serving as an intermediate reservoir and enhancing the flow of oil for forced lubrication.

Central Hole Also Considered

Cutting a large central hole through the entire assembly was also discussed. With a central hole it would be possible to balance the overturning moment above

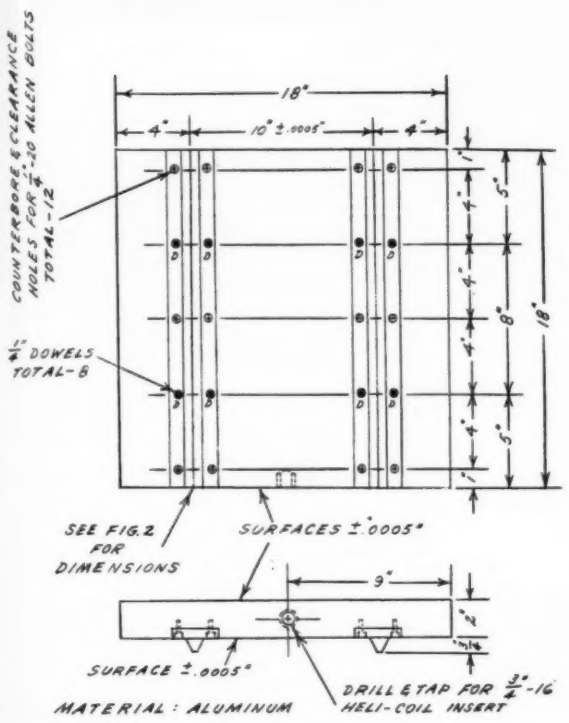


Figure 3
Dimensions of aluminum plate

the oil film with a restoring moment below the oil film. However, a central hole was not cut in the V-groove table.

The moving element of the V-groove table consisted of two steel V-runners attached to the underside of an aluminum plate. The support base was fabricated by covering an old surface plate with cast epoxy resin No. 11-B, manufactured by Furane Plastic Co., Los Angeles. With the V-runners attached, the moving element was coated with mold release and embedded in the liquid resin. The resin had 10 per cent of hardening agent No. 985 added, limiting it to a temperature rise of only 5°F. Thus thermal shrinkage was kept to a minimum.

The entire assembly was placed in a paint pressure tank and held at 80 psig for 48 hours while the resin hardened. Afterwards the two mating surfaces were blued and a few high spots were hand-scraped off the aluminum plate. The cast V-grooves had a trapezoidal profile with a ¾" altitude and a 60° included angle between the sides. The moving element measured 18" x18" x 2" and weighed 79 pounds with the steel V-runners.

Testing the Table

The V-groove table was mounted on its base and attached to a Calidyne Model 96A vibrator by means of a push rod ⅜" in diameter and 7" long. It was hoped that the push rod would be flexible enough to eliminate any cross-talk from the vibrator voice coil to the V-groove moving element. Sliding surfaces were coated with Esso Oil Millcott K-70.

A total of nine Model 2221 Endevco accelerometers were attached to the V-groove table as shown in Figure 1. The accelerometer marked number "4" measured the axial input of the rod to the table. Unfiltered accelerometer outputs were recorded with Type M-5000 galvanometers in a Model 110[illegible] Visicorder.

Accelerometer outputs were then read on an rms Hewlett-Packard Model 400 HR VTVM. The outputs were divided by their respective calibration values to obtain zero-to-peak g values. During the test, the input acceleration was kept to 10 g vector with a .1" double displacement limitation. The table was tested from 20 to 2000 cps.

Result: Excellent Condition

After the tests, the mating surfaces were found to be in excellent condition. The resin had offered an excellent sliding surface for the V-runners.

It was evident from the Visicorder records that the waveforms were not sinusoidal. Therefore, the acceleration values derived from the VTVM were not a good indication of the exact peak g values present at the particular forcing frequency. In addition, there was a good deal of movement of the base over the entire test range.

At present, it is not possible to make a quantitative statement when comparing the lateral motion of a V-groove and a flat oil film table. In the future, we plan to anchor the base of the table to the ground in a more rigid fashion.

Future Plans

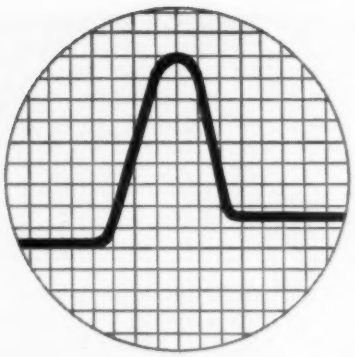
As a result of the tests, we plan to modify the oil film table to a V-groove table, cutting two oversized rectangular grooves in the granite block in an axial direction. The aluminum sliding element will have two rectangular grooves cut into it in much the same manner as shown in Figures 2, 3 and 4. Two hard-coated aluminum V-runners will be fitted into the sliding plate, and the sliding element will be coated with mold release.

Copper tubes, with vertical risers made of soda straws, will be placed in the rectangular grooves in the granite block. The grooves will then be filled with resin and the sliding plate, with the V-runners attached, embedded in the liquid resin. The entire assembly will be

(*Continued on Page* 18)

Dan Stern arrived at General Electric, Johnson City, N. Y., via NYU, the University of Maryland, the Navy and the Army. NYU awarded him his bachelor's in mechanical engineering in 1951. The next two years were spent as a marine engineer in the Navy's Bureau of Ships, whence he went into the Army as a guided missile technician until 1955. Then it was back to the Navy, as a mechanical engineer doing vibration testing and design work in the Naval Ordnance Lab., meanwhile earning his master's at Maryland (1957), until moving to GE in 1959. Dan is a member of IES, ASME and SESA, is a licensed P.E. in New York and has a patent for a safety shutoff coupling. He wants to acknowledge the contributions of J. J. Rogers, now retired, and J. Serkin, both of GE-Johnson City, and of W. G. Spodnewski of GE-Schenectady to the V-groove project.

Stern



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V-Groove Vibration Table

(*Continued from Page* 17)

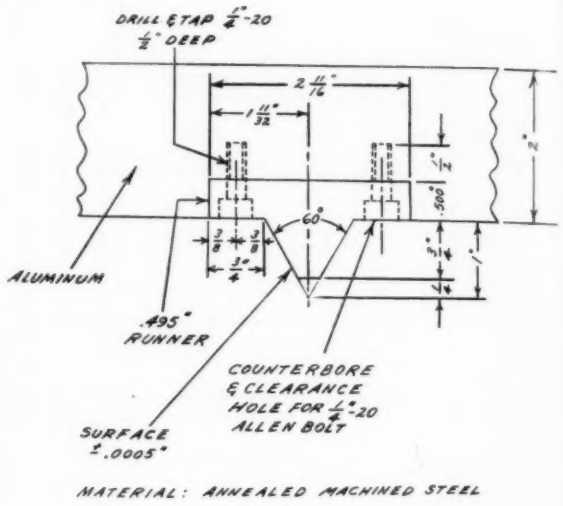

Figure 4
Dimensions of steel V-runner

pressurized to 80 psig for 48 hours. The resin will not be heated to eliminate the possibility of temperature shrinkage. After the resin has hardened, the two mating surfaces will be blued and scraped if necessary, and the copper tubing will be attached to an oil pump.

We feel the V-groove table will require less maintenance with forced lubrication and give a much higher degree of performance than a flat oil film table.

The Furane people have advised that No. 11-B resin, with 10 per cent hardening agent No. 985, can be heated to 100°F to facilitate pouring. At room temperature, the mix is somewhat viscous. Furane has also stated that it is desirable to invert the table when pouring so that any entrapped bubbles will rise away from the sliding surface. For best results, the resin and hardening agent should be mixed in a vacuum, heated to 100°F, poured at atmospheric pressure and set at 100 psig for 48 hours.

Resin No. 11-B has given every indication of satisfactory performance, even though it was not intended as an oil film bearing surface. However, the success of this resin does not preclude the possibility of some other resin performing just as well in a V-groove table. #

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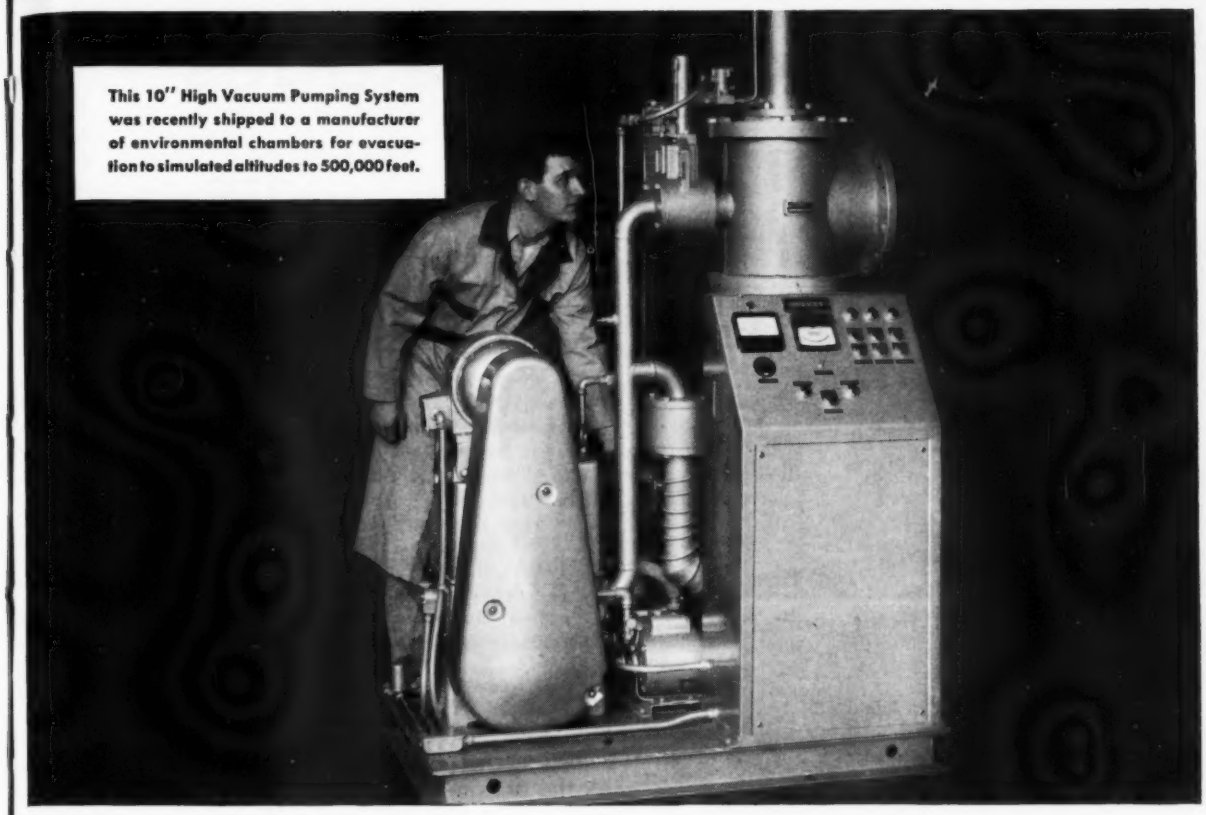

This 10" High Vacuum Pumping System was recently shipped to a manufacturer of environmental chambers for evacuation to simulated altitudes to 500,000 feet.

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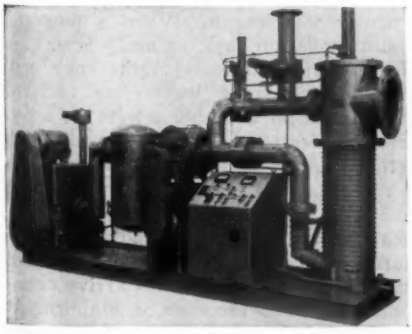

Designed to evacuate an aerodynamic wind tunnel facility, this specially designed unit features 3 stages; mechanical pump, Roots type blower and 16" diffusion pump. System is base plate mounted and includes a graphic control panel. The unit is one example of Stokes ability to meet out-of-the-ordinary system requirements.

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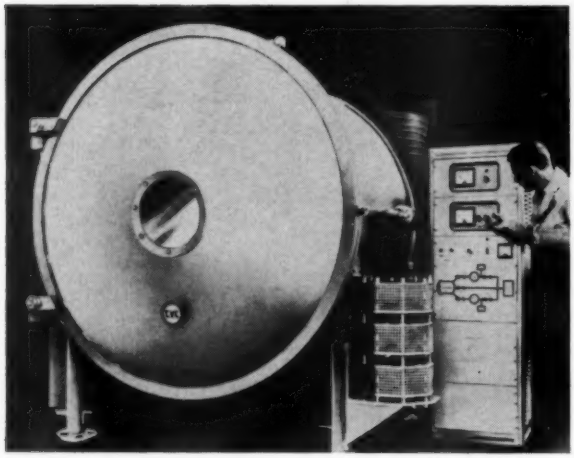
Electronic Packages vs. Space Torture



Thermal vacuum chamber at Aerotest Laboratories manufactured by Consolidated Vacuum Corporation.

by Arnold Pollack

General Manager
Aerotest Laboratories, Inc.

Electronic packages can survive in space when the designer keeps thermal effects in mind and checks his design by subjecting it to simulated space tests. While thermal design positions packages and brackets, and selects materials and coatings, thermal vacuum tests in space chambers prove out the design and locate trouble spots.

TO PROTECT TEMPERATURE-SENSITIVE electronic parts, the package designer must master two of the three modes of heat transfer: radiation and conduction. Heat pours into and out of the satellite skin by radiation, and electronic packages are bolted to the structure held by the skin, hence heat and cool by conduction. As for the third method of heat transfer, convection, above 300,000 feet there aren't enough gas molecules around to worry about it.

Radiation sends heat waves across a vacuum, and every surface above absolute zero radiates. The amount of heat emitted depends upon its absolute temperature (to the fourth power), surface shape and surface emissivity.

$$q = \Sigma\sigma\, FT^4$$

where q = heat flow/unit area, Σ = emissivity, σ = Stefan-Boltzman constant (5.673×10^{-12} watt/cm^2 Environmental Quarterly—O'Brien—Sept. 28, '61 .. .. °K^4), F = shape factor (1.0 for a flat surface) and T = absolute temperature.

Heat waves hitting a surface can be reflected, absorbed, or transmitted, or a little of each. Shiny aluminum, the usual satellite skin, reflects about 90 per cent of the energy it sees. The other 10 per cent is absorbed. Lampblack, by contrast, absorbs more than 94 per cent and reflects only about 6 per cent.

Radiation is not simple. Each atom emits a packet (quanta) of energy. The energy follows Planck's law and has a particular wavelength. When a powerful source like the sun sends out rays, so many atoms are excited that the spectrum of wavelengths they emit looks continuous. When these waves are received (absorbed), each atom of the absorber selects the wavelength that excites its electrons. They prefer to absorb these wavelengths. Hence, absorptivity varies with wavelength for each material. (Emittance varies with wavelength, too.)

Thus, the great bulk of ultraviolet radiation never reaches The Earth, because it is selectively absorbed by the ozone layer. The little that does arrive chemically changes material, as in the case of sunburn. At satellite altitudes—above the ozone layer—the satellite skin gets the full measure of UV from the sun, and some electronic packages have parts that ride outside the skin. Solar cells, antennae, camera lenses and so forth must be protected, therefore, from damaging UV with surface coatings like zinc sulphide.

A knowledge of radiation helps the designer to select skin materials, locate electronic packages and perform radiation calculations that are vital to thermal vacuum tests. Skin-sides that face the sun should be of polished aluminum (emissivity .08 at room temperature) to reduce absorbed heat. Sides that face the cold of outer space should be lampblack, to emit heat.

The rate of change in a package's temperature depends on net heat input and thermal mass.

$$dT/dt = Q/mc_{avg}$$

where dT/dt = the time rate of change in package temperature, Q = net heat input and mc_{avg} = thermal mass.

Thermal mass is the sum of all the weight-heat capacity products of the materials of the package:

$$mc_{avg} = m_1c_1 + m_2c_2 + m_3c_3 + \text{etc.},$$

and thermal mass tells where to mount each package in the satellite.

A package under a skin that changes from hot to cold should have a high thermal mass. High thermal mass reduces the swings in extreme temperature to which the package would otherwise be subjected. And the orbit controls which portion of the skin cycles hot and cold.

Combinations of the three basic orbits (Fig. 1) describe all skin conditions. Half of the skins of satellites in stabilized noon-midnight orbits always feel earth albedo (reflected sunlight). Stabilized here means "with one side constantly facing earth." The other skin half alternates hot and cold as it flies from sun heat to space cold.

In stabilized twilight orbits, packages with high thermal masses should be 90° away from the earth-line. These packages are under skins that also cycle hot and cold. Unstabilized flights should have high thermal mass packages nearest the skin.

Conduction Phenomena

Heat flows through "continuous" material by conduction:

$$q = k\ dT/dx$$

where k = thermal conductivity and dT/dx = temperature difference per unit length.

Small gaps interrupt conduction. Even bolted-on package covers have vacuum interfaces that force heat to radiate across from housings to the covers. And low temperature radiation is poor, almost insulating, in heat transfer ability.

With conduction the important internal heat transfer mechanism, brackets and mounting become critical. Brackets with low thermal conductivities (thermal insulators) can protect packages from heat inflow from a hot skin. Heat generators, resistors, tubes, batteries and the like can have their heat pulled away by good thermal conductive brackets. Usually, electrical and thermal conductivity correspond; good electrical conductors are good thermal conductors.

Designing for Heat

To help packages survive:

¶ Provide parts that dissipate heat with good conductive brackets—paths to thermal sinks. Welded or brazed brackets, encapsulated parts and thermal conductive but electrical insulating materials help deliver heat to the package surfaces.

¶ Use emissive surface coatings to radiate heat from a package to cold skin, but remember that the coatings will absorb heat from a hot side skin. Coatings can be striped emissive and non-emissive, corresponding to the internal bracket locations, to direct heat to a cold face.

¶ Use aluminum, a strong and highly conductive light metal. Magnesium, light and strong but a poor conductor, zooms local temperatures. Pack spaces in heat paths with aluminum-filled grease to conduct heat. Oils will flash off in space-vacuum, but low pressure (vacuum) greases have survived. High conductivity materials inserted in potted assemblies (like radio frequency mesh cast into epoxy) also aid heat flow.

Arnold Pollack became general manager of the 14-acre Aerotest facility in Deer Park, L. I., only two months ago. Under his supervision are areas for cryogenic, space environment, environmental, vibration, shock, acceleration, hydraulic, pneumatic, electrical, electronic, bi-propellant and gas dynamic testing. Before joining Aerotest he was head of environmental test and design at Airborne Instruments Laboratory, and before that he headed the environmental and vibration isolation department of Federal Manufacturing and Engineering Corp. He has also served as environmental consultant to many leading firms. Mr. Pollack is a graduate of CCNY and is a member of the IRE, ASME and ARS.

Pollack

Thermal Vacuum Tests

Thermal vacuum tests supply data vital to each space mission. A recorder used successfully in one orbit can fail in another. Each orbit path must be tested, although some contractors test only the "worst case." Component time-temperature traces are the prime output of these tests.

Satellite skin and substructure tests determine coating effectiveness, reflective/emissive mechanical and thermal properties and component package surface temperatures.

Some satellite skins are coated reflective or emissive, to combat solar heat or to radiate to space. Coatings, applied to the skin, are reliable. They stay in place and require no moving parts, an obvious advantage over mechanical assemblies. Coatings, however, suffer damage: sputtering from solar dust, UV attack, intense heat, high vacuum flashoff and intense cold. (Fortunately, sputtering has been found to be of minor consequence.)

The thermal vacuum chamber simulates the thermal effects of space. One of the two types of chambers used is the solar simulator, which subjects the satellite to the sun's spectrum and to space sink conditions. The second type is the thermal chamber, which radiates

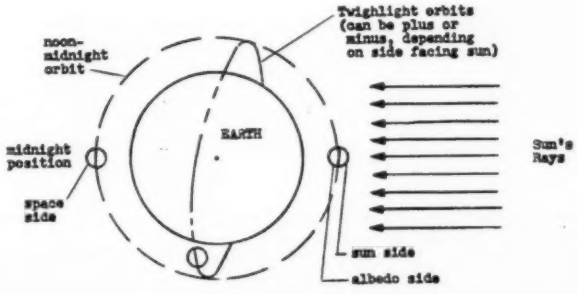


Figure 1
The three limit orbits for satellites

heat from its shroud segments or absorbs at the cold segments.

Use of Special Features

Occasionally, special features may be added. A thermal chamber's rig can rotate unstabilized satellites. Skins with solar cells that respond to exact spectral wavelengths require carbon arc, mercury-zenon, spotlight and/or quartz lamp inputs to match sunlight.

Thermal chambers, the test workhorses, require skin temperature calculations based on heat loading.

$$Q_{in} = Q_{sun} + Q_{albedo} + Q_{internal}$$
$$Q_{out} = Q_{to\ space}.$$

Radiation accounts for all supplied heat except $Q_{internal}$, which is developed from batteries or otherwise stored from launch.

Local skin temperatures, for weight of skin, w, and heat capacity, c, follows the form:

$$wc\,dT/dt = Q'_{sun} + Q'_{albedo} + Q'_{internal} + Q'_{skin} - Q'_{to\ space}$$

The prime signifies "into the segment under study." Q'_{skin} is the sum of cross radiation and cross conduction from other parts of the skin. Q_{sun} is about 340 BTU/hr. for each perpendicular square foot of area. Q_{albedo} varies from 100 to 180 BTU/hr. ft.^{2} depending on cloud conditions. And $Q_{to\ space}$ equals $\Sigma\sigma T^4$, since space is a perfect sink.

Q_{skin} and $Q_{internal}$ require computer calculation. Conduction from each bracket, each package and from adjacent skin and radiation from distant skin must be calculated. In effect, entire skin interrelations are programmed. Successive approximations—iterative procedures—yield skin temperatures and temperature changes with time.

The skin temperature solution is cam-programmed into the copper shroud, and the skin brought to the calculated temperature levels. Where possible, the whole satellite plus its electronic packages are instrumented and tested. Otherwise, the actual skin, substructure and full-size mock-ups of the electronic packages are used. These feel the vacuum and temperatures the packages receive in orbit. Thermocouples sense and record package surface temperature throughout the test.

Reflective/Emissive Assemblies

Many designs include reflective/absorptive systems. Venetian blinds, coated reflective and backed by an emissive subskin, open and close to reflect heat-waves when facing the sun or to emit heat to cold space. Another method uses reflective, emissive slats to interweave and give the same effect.

Here, the thermal vacuum chamber tests the actuation system in a space environment as well as the temperature matrix. The same calculations and techniques (used in coated satellites) yield the temperature matrix for the electronic package surfaces and tests the mechanical venetian blind system.

In complete satellite tests actual packages or mock-ups are used—the latter because most often skin design and fabrication are far ahead of component production.

Making mock-ups is a formidable problem, too. Heat loads are simulated, programmed if necessary. Brackets, internal heat transfer paths, surface (housing) coatings, thermal masses and surfaces are a few of the details to be matched by mock-ups.

Conduction heat transfer is linear with temperature

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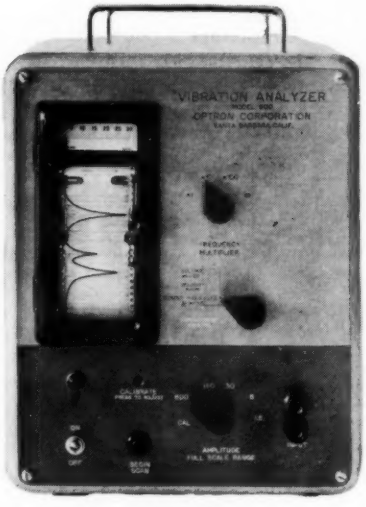

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difference. A doubled temperature difference drives twice the heat through the material. But radiation effects are not linear with temperature difference. Radiation depends upon the absolute temperature to the fourth power and disqualifies any chance of using small models to determine component packages temperatures.

The satellite skin receives most of its heat from the sun, only a minor fraction coming from the electronic packages. The skin temperature calculation is accurate, but package surface temperatures cannot be computed accurately. Yet package temperatures are critical. A few degrees more or less can alter calibrations or damage heat sensitive materials. While complete satellite tests do reveal surface temperatures for the electronic packages, even when mock-ups are used, the final electronic package tests must be performed on the actual packages.

These packages can be tested in a smaller chamber. Either full tests are programmed to match strip chart temperatures recorded during the complete satellite tests, or the "worst condition" is tested. Vital spots are "watched" by instrumentation, and at the conclusion of the test, the package is inspected for "unwatched" effects.

Most important to accurate testing is the test crew. When hot spots reveal themselves, the crew must stop the test and correct the design. They may alter bracket materials, change or stripe coatings, replace greases that sublime, insulate and isolate parts and use their ingenuity to reduce hot-spot temperatures. A test program demands a team of experienced specialists who know radiation, conduction and thermal vacuum testing. #

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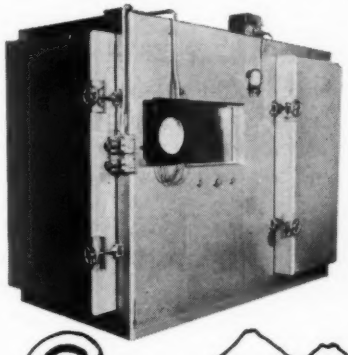

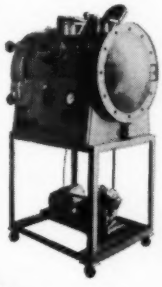

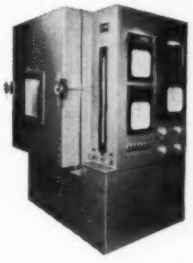

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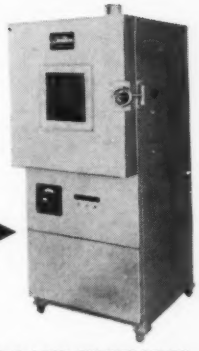

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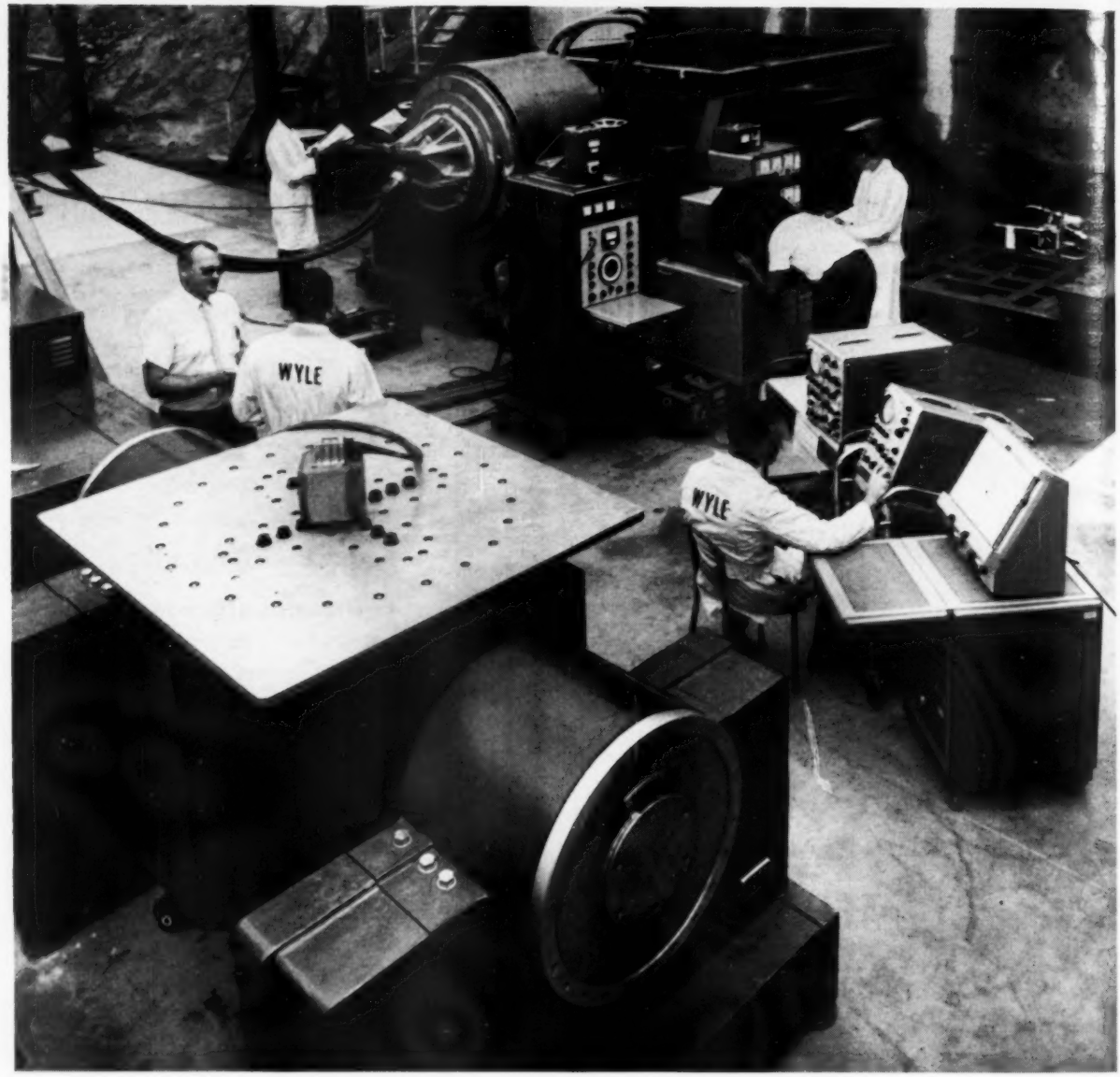

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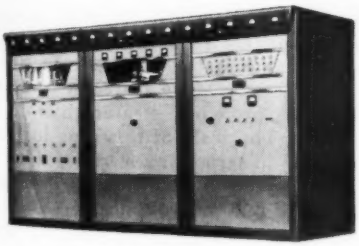

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LITERATURE FOR ENVIRONMENT...

Ling Electronics Division, Ling-Temco-Vought, Inc., Anaheim, Calif., describes Model RP-5/6-C power amplifier in a two-page, illustrated bulletin. Amplifier output is 5 kva, freq range is 5 to 10,000 cps; rated for continuous operation at full output. **(Circle EQ RSC #50.)**

* * *

Consolidated Vacuum Corporation, Rochester, N. Y., has published a unique, 54-page document entitled "High Vacuum Pumps." More than a year in preparation, it is an excellent primer as well as a lucid presentation of types and performance characteristics of a variety of vacuum equipments. **(Circle EQ RSC #51.)**

* * *

ITT's Industrial Products Division has an eight-page condensed catalog describing its vibration and shock test exciters, integrated test systems, oscilloscopes and other equipment. **(Circle EQ RSC #52.)** Also from the Industrial Products Division is a bulletin on the ITT Model 1201 series vibration test systems for use with the ST-100 series air-bearing, lateral motion vibration exciters. **(Circle EQ RSC #53.)**

* * *

Labline, Inc., Chicago, has a 200-page illustrated catalog of its entire line of instruments, apparatus, equipment and furniture. Products of Hudson Bay Co. and other subsidiaries, such as centrifuges, environmental test chambers, constant temp and utility baths, ovens and incubators, are shown. **(Circle EQ RSC #54.)**

* * *

Aerotest Laboratories, Inc.'s colorful and profusely illustrated 24-page brochure, "Creative Test Engineering," is available to those interested in the Deer Park, N. Y., laboratory's extensive environmental, hydraulic and aerodynamic facilities. **(Circle EQ RSC #55.)**

* * *

Phys-Chemical Research Corp., New York, has a four-page brochure on its electro-humidity transducer, a circuit element for sensing changes in relative humidity. **(Circle EQ RSC #56.)**

* * *

Roots-Connersville Blower, Connersville, Ind., division of Dresser Industries, Inc., has published a four-page bulletin on high vacuum booster pumps for environmental applications and vacuum processing. Units are two-impeller, dry-type compressors with pumping speeds from 310 to more than 30,000 cfm and "blank-off" pressure below .5 microns Hg abs. **(Circle EQ RSC #57.)**

* * *

Cincinnati Sub-Zero Products, Cincinnati, Ohio, has issued a 12-page booklet on expansion fitting. An illustrated case history, tables of expansion coefficients and monograms for calculating rates of thermal expansion are given. **(Circle EQ RSC #58.)**

Technology Instrument Corporation, Acton, Mass., has prepared a two-page illustrated bulletin describing a goniometer-chuck assembly for modifying potentiometers while in use. The assembly is a portable tapping kit complete with tooling and compact mahogany case. **(Circle EQ RSC #59.)**

* * *

Blue M Electric Co., Blue Island, Ill., offers a 64-page, pocket-size catalog of its complete line of electric ovens, furnaces, baths, environmental cabinets and related temp-controlled equipment. **(Circle EQ RSC #60.)**

* * *

General Vacuum Corporation, Medford, Mass., has a two-page illustrated bulletin on its Series 1450 vacuum pumping system that will reach 1 x 10^{-8} Torr. **(Circle EQ RSC #61.)**

* * *

F. J. Cooke, Inc., S. Norwalk, Conn., has a 24-page catalog on its high-vacuum systems, instruments and valves. Featured are high-temp, cold-jacket furnaces, special-purpose vacuum evaporators, ionization gauge control with automatic range switching and a series of right-angle cast stainless steel valves. **(Circle EQ RSC #62.)**

* * *

Fostoria Corporation, Fostoria, Ohio, offers an eight-page brochure discussing the principle and applications of radiant heat and describing electric infrared equipment. Profusely illustrated. **(Circle EQ RSC #63.)**

* * *

Lord Manufacturing Company, Erie, Pa., has issued an eight-page bulletin, No. 719, describing its damped laminates for control of structural resonant response. **(Circle EQ RSC #64.)**

* * *

Electric Hotpack Company, Inc., Philadelphia, shows 14 models of temperature-humidity chambers, ovens and walk-in rooms and seven Hi-Lo temperature test chambers in a new, 12-page environmental equipment bulletin. Hotpack's new FREEZ-PAK series of mechanical refrigeration temperature test chambers is introduced. **(Circle EQ RSC #65.)**

* * *

Ling Electronics Division, Ling - Temco - Vought, Inc., Anaheim, Calif. has a two-color bulletin, No. E/A-20, on its ESD-20/ASD-20 spectral density equalizer-analyzer, which permits continuous and parallel observation and control of the test spectrum. **(Circle EQ RSC #66.)**

* * *

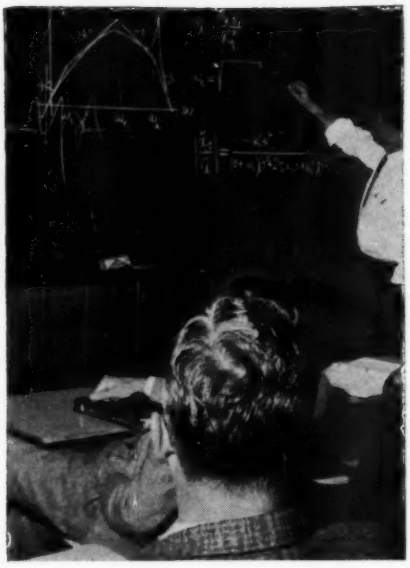
Ozone Research & Equipment Corporation, Phoenix, Ariz., has issued Brochure 113 on its Orec O_3R ozone recorders. **(Circle EQ RSC #67.)**

* * *

Endevco Corporation, Pasadena, Calif., has published a highly readable bulletin on its Model 2630 systems for vibration measurement in flight. A feature of the series is the insensitivity to length of cable from transducer to input. **(Circle EQ RSC #68.)**

Random Noise Generation and Measurement

by
the staff of
MB Electronics



Vibration seminar in session at MB Electronics.

"Random Signal Theory Definitions" in the July, 1961, issue of Environmental Quarterly introduced an exclusive, two-part article designed to provide a better background for an understanding of the language and specifications of random vibration testing, the design of electrical apparatus used to drive the shaker and basic measurement techniques. Prepared by MB Electronics, a division of Textron Electronics, Inc., the article is based on material presented in MB's popular vibration seminars. Herewith, the concluding installment.

THE NECESSITY OF HAVING a random noise signal generator in a complex motion system is evident. A wide-band random noise generator utilizing a thermal effect or a shot noise effect might be successfully designed, but by itself it would produce noise of such low spectral density that excessively large post amplification would be necessary to produce, say, an rms voltage of 5 volts over a bandwidth of 20 kilocycles.

A gas-filled diode is usually used as a noise source in inexpensive generators. The noise output is relatively high because of the massive ionization effect. The diode is usually placed in a DC magnetic field to reduce oscil-

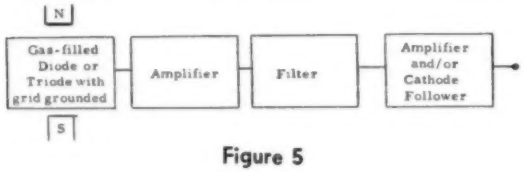


Figure 5

latory effects. A typical block diagram is shown in Figure 5. The General Radio Type 1390A random noise generator is of this general variety.

Measurement of RMS Values

Until a few years ago, measurement of true rms value of wide band voltages and currents was accomplished with thermal-effect instruments. This type of instrument has a low-overload capacity and is subject to easy burn-out if not used carefully. Now, several vacuum tube and transistor voltmeters which measure the true rms value of the input waveform are available commercially. These instruments may be subjected to large overloads without damaging the meter.

The Ballantine Model 320 vacuum tube voltmeter utilizes AC vacuum tube circuitry, with a diode squaring circuit and a conventional D'Arsonval meter movement. The squaring circuit produces a function g(v), which is linear by segments. The segmented function is made to approximate the desired square law by using a large number of segments. The D'Arsonval movement merely indicates the average value of the squared voltage, but the scale is arranged so that the true rms value is indicated. Other instruments utilize thermal-effect meters preceded by transistor circuitry, with protective devices, so that overloads will not harm the meter.

Gaussian Measurement

If the probability density of the voltage to be measured is truly gaussian, vacuum tube voltmeters which respond to the average value of the full wave rectified voltage may be used effectively. The instrument must have a good peak factor, probably greater than four times the full-scale value. The scale of this type instrument is usually calibrated in terms of the rms value of a sinusoidal input. It is therefore necessary to indicate a scale factor for use with random voltages.

The ratio of the rms value for a sine wave to the average absolute value is:

$$\left.\frac{\text{rms}}{\text{av}}\right|_{\text{sine}} = \frac{1}{\sqrt{2}}\,\frac{\pi}{2} = 1.11$$

For a gaussian noise the same ratio is:

$$\left.\frac{\text{rms}}{\text{av}}\right|_{\text{gaussian noise}} = \sqrt{\frac{\pi}{2}} = 1.25$$

Thus the scale indication of the above type of instrument can be multiplied by $\frac{1.25}{1.11}$ or 1.13 to yield the rms value of the gaussian random voltage.

Correlation Measurement

The degree of correlation measurement between two gaussian random voltages can be measured by a simple technique. The correlation between two random variables depends on the mean value of their product. It is assumed that the individual means are zero. A normalized correlation coefficient can be defined mathematically.

If random variables **x** and **y** are gaussian, the correlation coefficient also may be measured by applying the voltage representing **x** to the horizontal deflection amplifier of an oscilloscope, and the voltage representing **y** to the vertical deflection amplifier. For best results, the oscilloscope should have a long persistence screen. A shaded elliptical pattern results on the face of the oscilloscope, the pattern being brightest near the origin. The brightness of the pattern depends on the dwell time of the electron spot, and therefore the brightness is proportional to the joint probability density of **x** and **y**.

An ellipse may be drawn through points of equal brightness — equal probability density — and a phase angle measurement made from the resulting "Lissajous pattern" for the two noise voltages. The phase angle is given by $\theta = 2 \tan^{-1} \frac{a}{b}$, where "a" and "b" are dimensions of the ellipse, and are defined in Figure 6.

If the enclosing rectangle in Figure 6 is a perfect square, "a" and "b" become the axes of the ellipse. This

Figure 6

may be accomplished by adjusting the gain controls of the oscilloscope amplifiers. The normalized correlation cooefficient is then:

$$\rho = \cos\theta = \cos\left[2 \tan^{-1} \frac{a}{b}\right] = \frac{b^2 - a^2}{b^2 + a^2}$$

It can be seen that the correlation coefficient is analogous to the power factor for a sinusoidal voltage and current.

Measurement of Spectral Density

The measurement of the spectral density of a random variable as a particular frequency is generally accomplished by passing a voltage representing the variable through a narrow-band filter effectively centered at the desired frequency. The average properties of the filter output provide information about the spectral density. The details of various methods in frequent use will not be treated here, but several problems are common for all methods.

Given:

$$\sigma_o \cong \left[\frac{\pi}{2} S_i(f_o) B\right]^{\frac{1}{2}}$$

the rms value of the output accurately represents the spectral density at f_o only if the variations in S_i (f) are small within the bandwith of the filter.

Thus it would be desirable to have a filter with an infinitesimal bandwidth for accurate determination of S_i (f). The situation has two disadvantages. The measurement sensitivity becomes very small, and the required physical averaging time becomes very large, and some decision involving a compromise between accuracy and averaging time must be made. Knowledge concerning the typical behavior of spectral densities to be measured is valuable in making the decision concerning the filter bandwidth.

Measuring Methods

Methods commonly used for measuring spectral density in the audio frequency region can be divided into roughly four classes, as follows:

(1) The random voltage is applied to the input of one narrow-band filter, the center frequency of which is variable. The filter is followed by a detector, a low-pass filter and a display device, usually a meter.

(2) The random voltage is applied simultaneously to the inputs of a number of fixed narrow-band filters with their center frequency spaced so that the entire audio band is covered. Each filter may have a separate detector and low-pass filter, or the output of each filter may be sampled in succession by one detector, low-pass filter and display device.

(3) The random voltage is mixed with a sinusoidal voltage, the frequency of which is variable and usually much higher than the upper limit of the noise spectrum. The mixture is then detected and passed through a narrow-band filter with a fixed center frequency, usually located in the lower sideband of the spectrum resulting from the detection. The block diagram of the arrangement is shown in Figure 7. The variable oscillator frequency effectively sweeps the translated noise spectrum so that each portion may be sampled by the fixed filter. The detection scheme is similar to that for Method (1).

(4) The spectrum of the random voltage is translated as in Method (3) by an oscillator and heterodyne device. However, the oscillator frequency in this

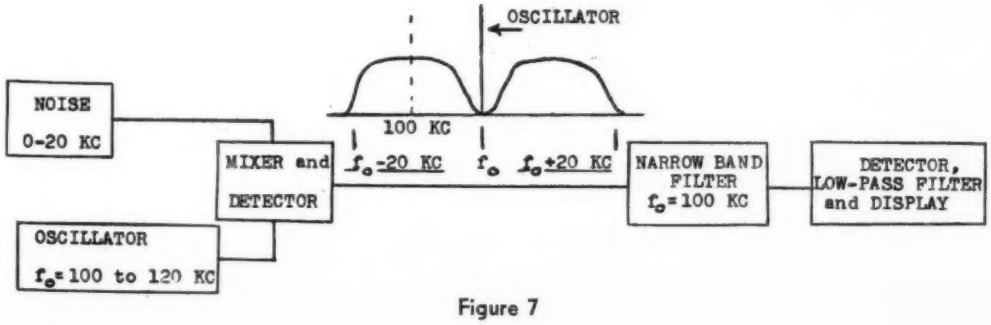


Figure 7

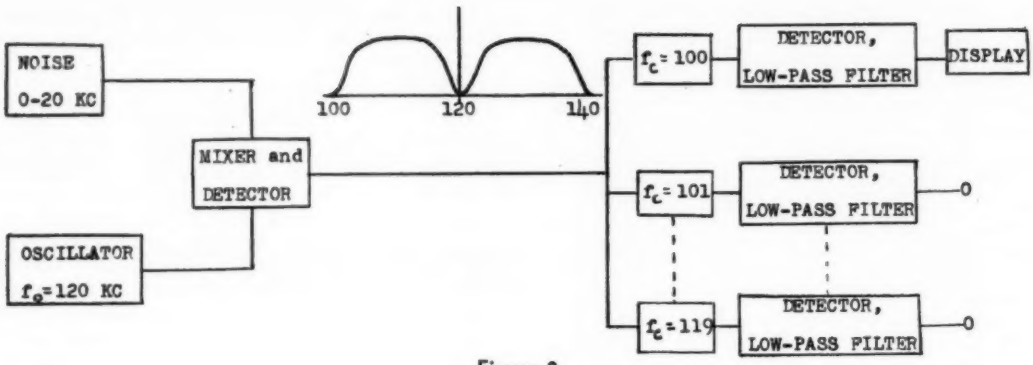


Figure 8

case is fixed. The translated spectrum is then sampled simultaneously by a number of fixed filters whose center frequencies are spaced so that the translated spectrum is completely covered, as in Figure 8. Detectors and display devices are similar to those in Method (2).

Comparative Advantages

Available commercial instruments falling in the four categories may also have various automatic features in addition to the basic properties described.

At present, Classes (3) and (4) find wider use than (1) or (2) because it is easier to construct a narrow-band filter at high frequencies using crystals or magnetostrictive devices than it is to construct an equivalent filter at low frequencies with resistors, inductors and capacitors. Class (3) enjoys an additional advantage over (1) because it is physically easier to sweep the frequency of an oscillator rather than sweep the center frequency of a filter.

Classes (3) and (4) may also be compared. Class (3) enjoys the advantage of requiring fewer components, mostly filters, than does Class (4), but the analysis time required by Class (3) is much longer. For swept-frequency analysis, the frequency sweep rate must be slow enough so that the filter output represents essentially the true steady-state situation. Fast sweep rates result in inaccuracy. The upper limit on the sweep rate $\frac{df}{dt}$ (in cps/sec) is given roughly by $\frac{df}{dt} \leq B^2$, where "B" is the bandwidth of the filter in cps. If there is a separate detector or demodulator for each narrow-band filter in Class (4), the commutation rate for the display device is limited only by the dynamics of the display device.

For the analysis of vibration spectra, an analyzer covering the frequency range from 10 to 5,000 cps is desirable. A device similar to the Rayspan seems to offer the best solution to analysis problems because the individual filter bandwidths are neither too large nor too small. The individual filter should be able to resolve a resonance having a Q of 100 at about 2,000 cps. This indicates a filter bandwidth of roughly 20 cps.

Measurement of Probability Density and Related Quantities

Measurement methods have been developed for three quantities which are important in specifying the amplitude properties of a random noise. These quantities are: The probability density function, the probability distribution function and the relative frequency of crossings at a particular amplitude level. The first two quantities are simply related, since the probability distribution function is the probability of the random variable being less than a given value. The functions can be measured and calculated mathematically.

The third property—relative frequency at crossing—is complicated to calculate mathematically for non-gaussian processes, but is relatively simple to measure. There are, to the authors' knowledge, no commercially available devices for the audio frequency range, but

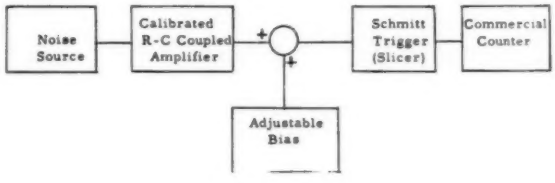


Figure 9

several experimental methods will be described. The relative frequency of crossings at a particular amplitude level can be measured by the scheme in Figure 9.

The Schmitt Trigger is in either of two stable states, depending upon whether the voltage at the input terminals is greater or less than a certain fixed level. The addition of the adjustable bias to the output of the R-C coupled amplifier allows the switching of the Schmitt Trigger to take place at different levels relative to the noise waveform. The commercial counter merely meas-

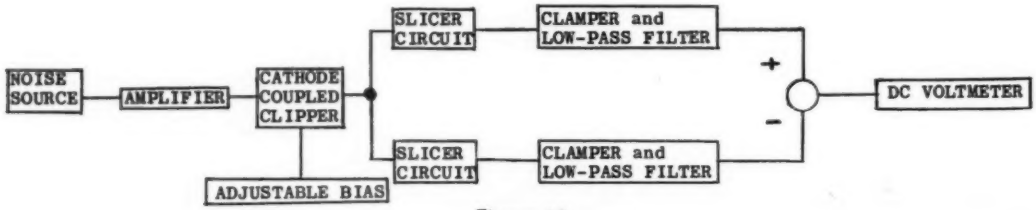


Figure 10

ures the number of times the Schmitt Trigger switches in a given time interval. The level at which the frequency of crossings is being measured may be changed by changing the bias voltage.

One method of measuring the probability density involves a scheme somewhat similar to the oscillographic technique described in the correlation measurement section. The probabiloscope uses the relative brightness of a particular area on the oscilloscope screen to indicate probability density, and employs an optical wedge to provide a plot on photographic film of probability density as a function of the random variable amplitude.

Another Measuring Device

Another device for measuring probability density involves an extension of the circuit in Figure 9. The Schmitt Trigger in Figure 9 can be generally called a "slicer" circuit. The extension is found in Figure 10.

The output of the cathode coupled clipper is merely a reproduction of a limited portion of the input. The input interval of interest can be changed by adjusting the bias control on the clipper circuit. The two slicer circuits are adjusted so that they switch at slightly different voltages. The average output of each slicer channel is therefore proportional to the probability distribution function at two slightly different levels. The difference between these two voltages as registered on the voltmeter is therefore proportional to the probability density.

The accuracy of the device in Figure 10 is not good because drift in the interval between slicing levels causes an error in the output. For amplitude analysis of random vibration, it is desirable to obtain accurate data for amplitude levels which are three to four times the rms value. At these high amplitude levels, the value of either the density function or the distribution function is quite small, or in the case of the distribution function, may be very nearly unity. Due to the very small expected values of these functions, it is felt that the two devices just described will not perform adequately at these high levels, mostly due to the limitations of the data recording techniques.

It is felt that devices employing slicers and level selector circuits to measure probability distribution of density functions should have low drift and also employ decade counters for accurate measurement at high amplitude levels. #

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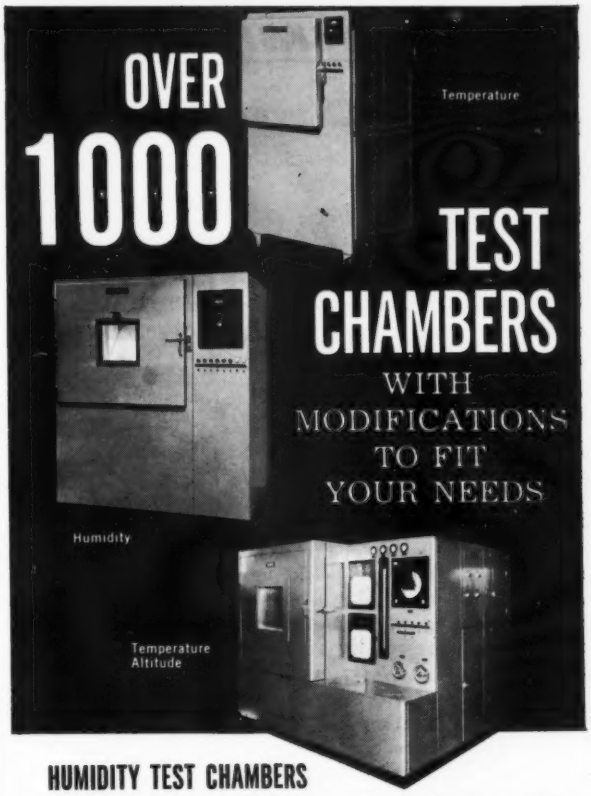
ENVIRONMENTAL QUARTERLY



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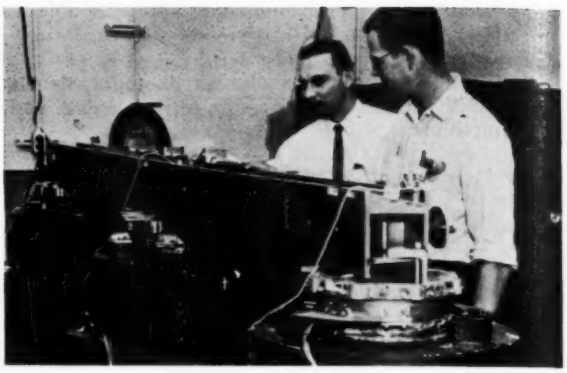
ENVIRONMENTS IN USE...

For an Extra-Large Specimen: Shakers in Tandem

The Problem: For the Hound Dog program, Boeing Airplane Company, Seattle, had to vibration test the Collet lock and release mechanism. The item had to be mounted in a jig to simulate actual mounting conditions, ordinarily a simple procedure but not in this case. The Collet mechanism is more than 10 feet long.



Illustrated is the first magnesium vibration fixture, 12 feet long and 184 pounds in weight, built at Boeing. Three shaker pots were used, each with a capacity of 750 pounds. Force of 10 Gs was exerted in the test.

THE SOLUTION: The vibration environment and the procedure of the qualification test is spelled out in Boeing documents. For this particular test, the holding fixture was to simulate the actual airplane structure.

Since the Collet mechanism is so big, an extremely large fixture was required to mount it properly on a single vibrator and uniformly subject it to the required input. Mounting an item this large not only presents control problems but limits the force capability of the shaker.

To satisfy mounting conditions and simplify jig design, several vibrators designed and manufactured by Boeing were used. They have a nominal force rating of 800 pounds peak and an armature coil weight of 35 pounds. The armature head has nine attachment points and is cantilever leaf spring suspended.

Three Vibrators, Magnesium Jig

The size problem was solved by using three vibrators in series, providing a uniform distribution of force with a rating of 2400 pounds. The jig was fabricated from magnesium and provided the necessary saving in weight so that the "G" (acceleration) input value could be met.

In using vibrators in series, it is important to connect them so that their phasing is correct in relationship to each other. Correct phasing assures the proper distribution of force in a single system driven by a combination of vibrators. Equal force distribution is, of course, based on the assumption that the armature of each vibrator has the same resistance and an equal amount of turns. If they are then connected so that the current travels in the same direction in each armature the phasing and force produced by each vibrator will be equal.

Phasing of the vibrators was checked by connecting the output of two accelerometers into the X and Y axis of an oscilloscope. When one accelerometer is moved to another shaker, the Lissajous pattern display should remain the same. If it does not, one shaker is out of phase with the other and the armature leads must be reversed. Phasing of shakers can also be checked by setting the oscillator to a low frequency, say 2 to 5 cps, and visually observing shaker action. Phasing should be done before the fixture is mounted on the shakers.

Control Problems

Control of shakers may be difficult when testing a large specimen, usually due to jig resonances. To overcome the loss of control at specific frequencies, it may be helpful to control the field strength of one or more of the shakers; where this does little to remedy an uncontrollable condition, changing the jig is the only solution.

In conducting this test the following specifications were defined: (1) Conduct resonant frequency scan. (2) Endurance test for each resonant condition. (3) Cycle test the item with actuation of the system at the completion of the specified period.

The frequency scan defined the resonant conditions of the test part. Conducted at a low "G" level, it determined the frequencies at which the endurance testing was conducted. Endurance testing was accomplished by subjecting the test item to a dwell at the resonant condition for a specified period of time. As defined in the Boeing specification, the length of time was the accumulation of a million cycles or a maximum of 8 hours, whichever occurred first. The cycling test subjected the item to the specified "G" level through a frequency band.

Monitoring the G-Level

The vibrator G-level was monitored with Endevco Series 2200 accelerometers in conjunction with associated cathode follower, power supply and amplifier. Their outputs were read on a VTVM, and wave shapes were observed on an oscilloscope.

With the test set up, a preliminary scan was conducted and frequencies at which a resonant condition existed were noted. Once these were determined, the part was endurance tested for a million cycles for each resonant condition, and the mechanism was test fired at the end of each, while vibrating.

The last part of the test was subjecting the test item to a cycling test through a frequency band.

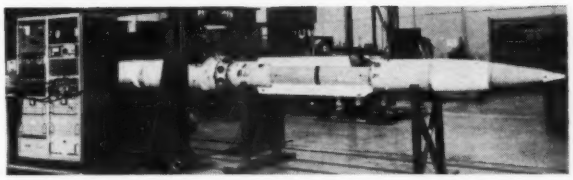
The test procedure was followed for the three axes of vibration.

Although there was considerable wear of the test part, because of the many hours of severe testing, it operated successfully throughout.

—T. S. Modzelewski, Boeing, Seattle

For a Whole Missile: Every Shake in the Book

The Problem: Field and shipboard weapons, such as the Navy's advanced Terrier and Tartar missiles, and the Army's Redeye and Mauler, are exposed to rough handling and abuse all the way from the factory to blast-off. Engineers at the Pomona plant of General Dynamics Corporation's Convair division had to prove prototype reliability under such conditions as transportation shock, a rolling destroyer and actual firing.



Double set of hydraulic actuators subjects an advanced Terrier prototype to complex vibration and shock in this Convair-developed vibrator. Motion in vertical lateral or longitudinal directions is controlled from the console at left.

THE SOLUTION: Unable to find a commercially available testing machine large enough to hold an assembled missile and capable of the variety of effects needed, Convair's Pomona engineers built their own. Double sets of piston-type hydraulic actuators were used, set opposite each other, one pushing against the other. With a four-way valve directing high-pressure hydraulic fluid to first one actuator, then the opposite, according to an electrical signal from the test unit's control center, the effect is to push and pull the missile in a precise vibration pattern.

In a typical installation, six sets of actuators operate simultaneously on the missile, which is hung in a horizontal position in a heavy steel framework with a massive concrete pillar at one end. Three sets vibrate the nose of the missile up and down and sideways; the other three do the same thing to the tail. Meanwhile, a single actuator vibrates the missile lengthwise.

Each motion can be programmed separately, so that an almost infinite variety of vibration effects that can be achieved within the frequency limits of the test gear. Displacement in any of the five directions can be as much as 1 inch. Total force exerted on the missile varies up to 10 tons.

Actuators Are Adjustable

Most of the actuator pairs are mounted so that they can be moved or adjusted according to the requirements of the job. Sometimes a single pair is used in a remote corner of the laboratory to test the reliability of a single missile component. Other times, several are brought together for tests that may take months to complete. Resonant frequencies create standing waves in the missile structure, and care is taken that joints between missile sections are far removed from areas of maximum stress created by these waves.

Engineers responsible for instrumenting the missile also study the data to find node points, where motion due to vibration is essentially zero. Inertia and pressure sensing devices mounted at these points are not distorted by vibratory effects. #

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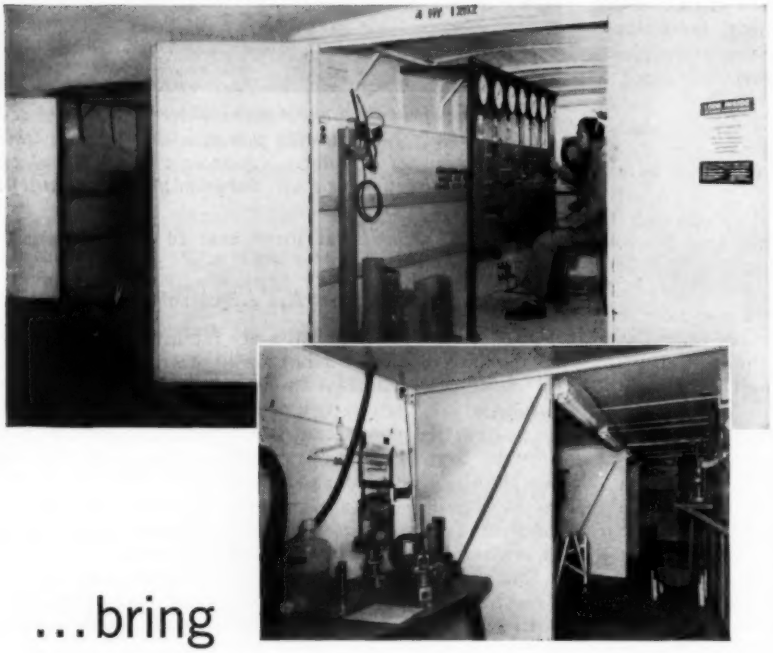

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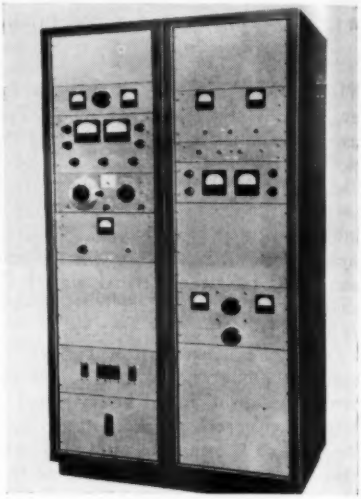
NEW PRODUCT

Ling Electronics Introduces Space-Saving Sine-O-Matics

Ling Electronics division, Ling-Temco-Vought, Inc., has introduced two new models in its Sine-O-Matic series for driving electrodynamic



Space Saver Model RP-5/6-C

shakers in vibration testing. Upright, space-saving design requires only 7.7 square feet of floor area.

Model RP-5/6-C has a power output of 5 kva; Model RP-¾-C, 3 kva.

The compact consoles house field and degaussing supply, cycling oscillator, servo system, metering and controls. Frequency range of both models is 5 to 10,000 cps, with frequency response of ±1 db from 10 to 10,000 cps.

Full output voltages are available from 20 to 10,000 cps; below 20 cps, voltage is proportional to frequency. Full output current is available from 5 to 10,000 cps. Total harmonic distortion is said to be under 1 per cent in the 50 to 50,000 cps range and less than 3 per cent between 10 and 7,000 cps.

Rated for continuous operation at full output, the systems are also available in a desk-type console design. **(For more info circle EQ RSC "A.")**

King-Size Oil Diffusion Pump by CVC Can Reach 2×10^{-9}

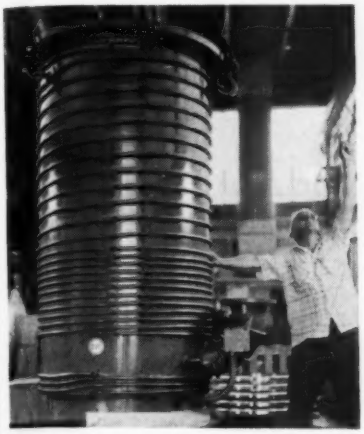
Consolidated Vacuum Corporation has enlarged its PMC line with a 32-inch diameter oil-diffusion vacuum pump, said to be the largest of its kind in the high-vacuum field.

The pump, Type PMC-50000, was developed for rapid, clean evacuation of the large chambers used for space simulation studies. Other applications are in the fields of vacuum metallurgy and chemical processing.

Claimed capacity is 52,000 liters per second at pressures between 3×10^{-6} to

NEWS...

$4x10^{-4}$ mm Hg. The pump is designed to provide baffled ultimate pressure of



PMC 50000: "Largest" Claimed

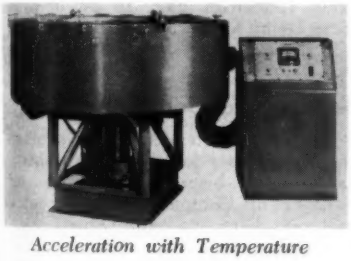
$2x10^{-9}$ mm Hg and a backstreaming rate of only .194 mg/cm²/hr.

A 4-stage nozzle assembly ejects oil vapor at supersonic speeds.

Annular aluminum rings with cast-in tubular heaters are inserted in concentric wells to form three circular, interconnected compartments in the pump boiler. Rapid convection in these compartments minimizes fluid decomposition. **(For more info circle EQ RSC "B.")**

Schaevitz Unit Provides Extra Environments for Any Simulator

Schaevitz Machine Works has developed a temperature control unit, Model TCU-310-A, which can be



Acceleration with Temperature

coupled to any physical simulator to provide combination environmental testing. The illustration shows a unit joined to a rotary accelerator.

Temperature can be maintained automatically within ±2°F over the range of −100° to +200°F.

The TCU-310-A is equipped with heating and cooling chambers, an oversized, motor-driven centrifugal air blower, five 2,000-watt heaters capable of producing 34,000 BTU/hr, selector switch, solenoid control for use with 1,000-psi liquid-CO_2 bottles, three thermocouples and control panel. The all-steel unit is 51x33x31" deep and weighs

9639

When you want it CO_2LD

. . . call Mathieson

Even in the penguin's native habitat of Antarctica, the temperature rarely drops below −109.3°F. But you can achieve that frigid mark quickly and economically with Mathieson carbon dioxide in your environmental test chamber. With carbon dioxide, you can cold test well below the limits of government requirements.

The Olin Mathieson network of warehouses assures round-the-clock deliveries of carbon dioxide by truck or rail. Small user or large . . . cylinder, dry ice, or bulk liquid CO_2 . . . rely on Olin Mathieson for speedy deliveries. Write us for the booklet giving data on uses, storage and technical information. **Olin Mathieson, Baltimore 3, Maryland.**

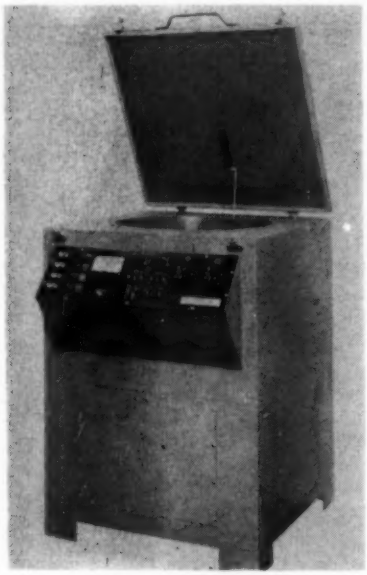
CHEMICALS DIVISION Olin

about 550 lbs. Power required is 220 v, 60-cycle, single phase.

Optional features are wider temperature ranges, temperature-time proportioning and temperature programming. Casters are available. **(For more info circle EQ RSC "C.")**

Rotary Acceleration Generator Designed by Pacific Scientific

Pacific Scientific Instrument Laboratories has announced a new rotary acceleration generator designed for testing accelerometers, transducers,



Rotary Acceleration Generator

small flight packages and other instruments requiring high "g" qualification. The unit, Model RA-ATC-500-1, has a 20-inch diameter spin table and can produce accelerations from 3 to 500 gs.

Numerous ¼-inch tapped holes at radii from 3 to 9 inches are provided for securing test objects and fixtures. Dual controls can produce infinitely variable platform speeds within an operating range 10 to 2,000 rpm. Two speed indicators provide for direct readout on a panel mounted meter and for electronic counter readoff.

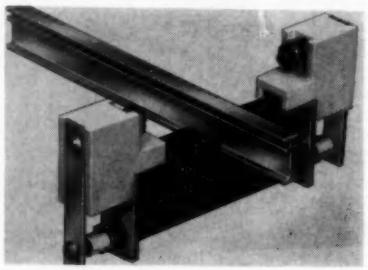
Safety features include dynamic braking and relay overload protection. A safety switch prevents operation when cover is open.

The unit is 40"x29"x29" deep and weighs 600 lbs. No special flooring or anchoring is required. Power supply is 115 v, 60-cycle.

Optional equipment includes Stroboconn counter, E put meter, 20-position rotary switch, line voltage regulator and associated air oil systems. Basic price is $3,400, fob. **(For more info circle EQ RSC "D.")**

Fostoria Enters Environmental Field with Radiant Heaters

Fostoria Corporation has entered the environmental test field with a new



New Radiant Heaters

line of radiant heaters, the 1211 Series, for high vacuum cryogenic testing.

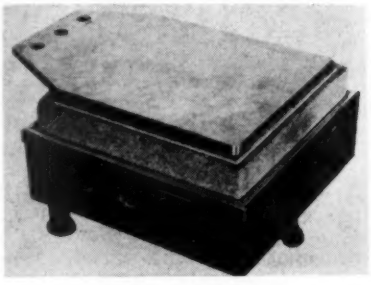
A unique feature of the units is compact size, which enables collection of 250 per cent of solar heat with obscuration of the "heat sink" walls of the enclosure of about 5 per cent.

Program controllers permit duplication of solar patterns encountered by a missile in orbit, including passage into the shadow of the earth.

The heaters contain tungsten heat sources and are designed to eliminate outgassing from either materials of construction or trapped air pockets. They are suspended from miniature anodized "I" beams. **(For more info circle EQ RSC "E.")**

'Vibraplane' Test Fixtures Up Maximum Usable Frequency

A new line of horizontal vibration test fixtures, designed to increase maximum usable frequency by 60 per cent,



Frequency Raiser

has been announced by MB Electronics, a division of Textron Electronics, Inc. The line is known as Vibraplane.

Four models are available with table dimensions of 20x20", 30x30", 40x40" and 48x48". Through table redesign, maximum usable frequency of the 20x20" model has been increased from 1,200 to 2,000 cps for large specimens. Smaller specimens can be tested to higher frequencies, and similar increases have been achieved in the larger models.

The Vibraplane consists of a magnesium specimen table that slides on a polished granite block. The table is driven by a standard vibration exciter rotated 90 degrees from vertical to provide driving force in the horizontal plane. Bolts are used to attach specimen to the table. **(For more info circle EQ RSC "F.")**

* * *

RADC Issues Supplement To Reliability Notebook

A major, 215-page revision of a portion of its "Reliability Notebook" has been issued by Rome Air Development Center through the Office of Technical Services, Department of Commerce. The Notebook, published in 1959, is a basic handbook on electronic equipment reliability.

The new Supplement 1 enlarges and brings Section 8, entitled "Parts Reliability Factors," up to date. It is available at $3.50 from the OTS. Order number is PB 161894-1.

'Understanding Reliability'

C. E. Leake, reliability manager for United Testing Laboratories, Monterey Park, Calif., has written a new 150-page textbook, "Understanding Reliability." The publisher is Pasadena Lithographers, Inc., 49 East Walnut, Pasadena, Calif.

Sub-Zero Chiller at New Delhi

Ultra-low temperature equipment of Cincinnati Sub-Zero Products, Cincinnati, Ohio, will be an integral part of processes to be shown in a metal treating facility in the U. S. exhibit at the India Industries Fair, to be held in New Delhi for three months starting Nov. 15.

Bernstein to CompuDyne

Jack H. Bernstein, formerly production superintendent at Stromberg-Carlson, has been appointed general manager of CompuDyne Electronics, Inc., subsidiary of CompuDyne Corporation, Hatboro, Penna. The company manufactures computer operated automatic control systems and related instrumentation.

Two GE Contracts to GVC

General Vacuum Corporation, which moved earlier this year from East Boston to expanded quarters in Medford, Mass., has received contracts from GE's Light Military Electronics Dept. and Bendix' Radio division. Both call for chambers that will deliver 1×10^{-8} torr or higher, with extreme temperatures. The GE chamber will have a 42"x60" long work area, the other 48"x96".

where on earth

Where on earth can you test components and systems under the extreme conditions encountered in space flight? At the Aerotest Space Environment Center, the most advanced facility of its kind, with the specialized equipment necessary to simulate and program the varying environments of space flight. Here a team of experienced scientists and technicians conducts extensive test programs with a unique complex of advanced apparatus, including:

THERMAL-VACUUM CHAMBERS, simulating conditions of space 130 miles up, that test space component reactions to heat of friction and radiant heating.

BI-PROPELLANT FACILITIES to test for internal and external compatibility with Nitrogen Tetroxide, UDMH, and Hydrazine, under simulated environmental conditions.

VIBRATION AND SHOCK TESTING facilities providing sine wave, complex motion, and combined environment testing for space components and systems.

LOX AND HYDRAULIC CLEANING PROGRAMS that eliminate all foreign particles larger than 2 microns from components of missile fuel or control systems.

CRYOGENIC FACILITIES for flow testing components and systems.

More information on Aerotest's Space Environment Center, plus technical and cost proposals, are available without obligation.

AEROTEST
LABORATORIES, INC.

Comac Road, Deer Park, L.I., N.Y.

NEW PRODUCTS...

A READER SERVICE CARD requiring no postage is bound into this issue of ENVIRONMENTAL QUARTERLY for the convenience of readers desiring additional information on advertisements, new products, new literature (Page 45) and other announcements. Reader Service Card numbers and letters are keyed in the text as "EQ RSC."

SPOTLIGHT ON:

Humidity

New temperature - humidity chambers designed for broad range of applications have been announced recently by such manufacturers as Tenney Engineering, Inc., Associated Testing Laboratories, Inc., Blue M Electric Company and Wyle Laboratories.

Features variously available include liquid CO_2 and mechanical refrigeration, 20 to 95% relative humidity, temperatures in the range of —100 to +350°F, stainless steel construction and caster mountings.

* * *

Mechanical Upright

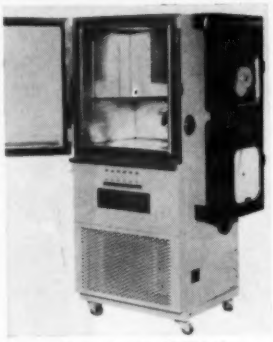
Providing the relatively large test space of 5.1 cubic feet in a compact cabinet, **Tenney Engineering, Inc.'s Tenney-Mite TH, Model TMTH0200,** is designed for MIL-E-5272C, MIL-STD-202B and MIL-STD-170 testing. It provides temperatures from 0° to +200°F and relative humidity from 20% to 95% in the dry bulb range, limited only by +35° to +185° dew point.

Pull-down from +70° to 0°F takes about three-quarters of an hour, while heating from +70° to +200°F requires approximately one hour.

Work space, with a heli-arc welded, stainless steel liner, is 21" x 25" x 17", while the exterior measures 26" x 62" x 33".

The Tenney-Mite TH, which has been made part of the standard Tenney line, can be mounted on casters and requires no auxiliary equipment. Optional accessories include window, light, windshield wiper, terminals and ports. Instrumentation is available as required. The unit is said to be the lowest-priced mechanically refrigerated, temperature - humidity equipment in the Tenney line.

(For more info on Tenney's Tenney-Mite TH Circle EQ RSC #1.)



Tenney's TMTH0200
Low cost, large space

* * *

Non-Mechanical

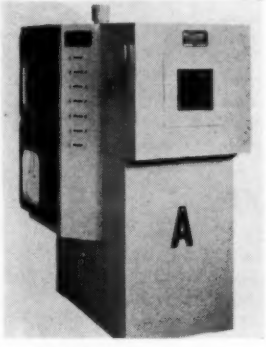
A major breakthrough is claimed by **Associated Testing Laboratories, Inc.**, with a temperature-humidity test chamber that has no mechanical refrigeration system either for low temperature or dehumidity conditions.

Priced at $2,675 F.O.B. Wayne, N. J., with immediate delivery, the **Econ-O-Line Low-High** temperature - humidity chamber **(Model ELHH-4-LC)** has internal working dimensions of 18" x 18" x 18" and contains no mechanical components that may break down.

Liquid CO_2 pulls temps as low as —100°F and controls humidity in the 20 to 95% RH range. The chamber's high temperature range is +350°F.

Standard equipment includes a two-pen-two-cam programming recording controller.

(For more info on ATL's Econ-O-Line cabinets Circle EQ RSC #2.)



ECON-O-LINE by ATL
Wide range, CO_2 simplicity

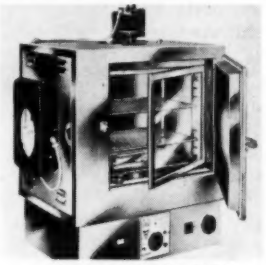
* * *

Bench-Type

Bench-type **Model BM 620R,** by **Blue M Electric Company,** tween 25° and 65°C, ± 1°C, with constant humidity claimed within ± 1% through the complete cycle.

Guaranteed to meet specs of MIL-202B, Method 106A, Steps 1-6, the unit's capacity is said to be suitable, too, to include Method 103A, Procedure 2.

An infinitely-proportional control system does not utilize contacts or arcing devices, and there are no cams or compressors. Wet and dry-bulb controls are guaranteed for straight-line performance.



Blue M's Model 620R
Automatic, constant

Four interior sizes are available from 14" x 13" x 14" high to 37" x 19" x 25" high. Construction is of stainless steel.

Model BM 620R is furnished with 12" diam wet and dry-bulb recorder, 24-hr program timer and shielded conditioning chamber. Power suply is either 115 v or 230 v, 60-cycle, single phase.

(For more info on Blue M's BM 620R Circle EQ RSC #3.)

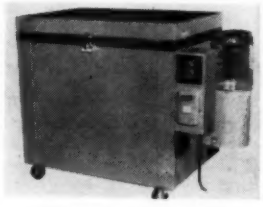
* * *

Top-Opener

From **Wyle Laboratories'** Manufacturing division comes a 6-cubic foot, portable self-contained, automatically controlled humidity chamber, **Model H-104,** with relative humidity of 95%, ±5%, at a dry bulb temperature of 160°F. A variable setting thermostat permits selection of other dry bulb temperatures.

The chamber's interior is of heliarc welded stainless steel, sloped for condensate drainage and to prevent spillage on exterior surfaces. Fiberglas insulation is used.

A fail-safe temperature control system operates if the inside temperature exceeds a predetermined limit. Heaters then go off and a red warning light goes on, on the control panel.



Model H-104 of Wyle
95% at 160°F dry bulb

A programmer permits humidity time cycles in conformance with MIL-E-5272C.

Model H-104 operates on a standard 110 v, 60 cycle, single phase current.

(For more info on Wyle's Model H-104, Circle EQ RSC #4.)

* * *

Humidity Controller

The **Hygrocon-1,** by **Phys-Chemical Research Corp.,** is said to permit control of relative humidity in any enclosure to within less than 1% throughout the entire rel hum range at temps as high as 180°F.

A humidity reader as well as humidity / dehumidity controller, the Hygrocon-1 gives readings directly in % on a 4" panel

E. W. A.

(Environmental Want Ads)

Rates: $5 (minimum) for three lines, $2 per line additional. **"Situation Wanted" ads free** (except for reply box number) to those who can reasonably expect to find employment in the environmental industry, but prescribed form (given below) must be followed. First three lines free to those who write own "Situation Wanted" ads. **Reply code number $2,** but no charge for handling replies. **Payment in full with copy, except from recognized agencies.**

Deadline March, 1962, issue is Feb. 10, 1962. Send order, copy, payment and all inquiries to Environmental Want Ads, Environmental Quarterly, 252-46 Leeds Rd., Little Neck 62, N. Y. **For classified display information, write for rate card.**

For free "Situation Wanted" ad give only following information in this order: Job title (two permitted), age, (if desired), degrees, recent experience, salary desired, where you prefer to work and name and address. (Last two will be withheld if reply code is used.)

SITUATIONS AVAILABLE

REFRIGERATION TECHNICIAN

To work on development of low temp and special refrig equipment. Must know theory and have experience in construction, piping and wiring. Knowledge of environmental test equip helpful. Stimulating, rewarding, permanent position with quality manufacturer. Write fully with salary expected.

EQ BOX #25

PROFESSIONAL CARDS

MAXWELL LAZARUS
Reg. Engr.
Vibration, Shock, Dynamics, Consulting, Prototypes, Production
Isolators, Special Structures, Test Fixtures
1197 Beacon St. AS 7-8190
Brookline 45, Mass.

meter. A selector dial provides four individual 25% ranges and one full 0 to 100% range.

All ranges are automatically temp compensated by thermistor networks. Calibration accuracy in the 25% range is ± .25%.

Hygrocon-1 operates on 115/230 v ac or dc. Price: $750, fob, with single sensing unit and housing and cable.

(For more info on the Hygrocon-1 Circle EQ RSC #5.)

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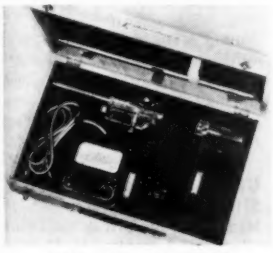
Portable Psychrometer

Model A+ Hygrophil, by Atkins Technical, Inc., gives wet-bulb and dry-bulb readings for determining rel hum, absolute humidity, dew point or enthalpy



Atkins' A+ Hygrophil
Readings within seconds

in air and other gases. Both wet and dry readings are said to be obtainable within 10 sec. in a temp range from 10° to 176°F, ± .5°F.

The humidity range of 10% to 90%, ± .5%, is suitable for calibration quality measurements.

Instrument uses thermistor beads as resistance thermometer elements. Air speed is controlled by built-in fan system. Lined wooden or plastic case is supplied complete with barrel extension piece, distilled water container, extra wicks, operating instructions and booklet of dew point and relative humidity tables.

For explosive atmospheres, there is a spring-wound fan motor.

(For more info on Atkins Technical's Hygrophil, Circle EQ RSC "Q.")

* * *

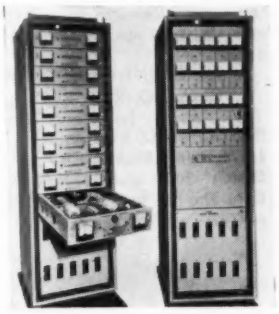
COMBINED SHOCK, VIBRATION TESTER

Model ST-300 by **ITT Industrial Products division** utilizes lateral motion excitation and air-bearing support. Exciter delivers 250 force pounds. Useful freq from 5 cycles to 50 kc; shock testing to more than 5,000 gs. First major resonance is above 5 kc. No significant distortion through normal test range. Table size: 5" x 8".

For More Information
Circle EQ RSC #6

COMPACT AC POWER REGULATORS

Models Y4079 and G4078, by **Research, Inc.,** control power to ovens, furnaces and similar devices in direct proportion to



signals from set point meters, temp controllers, programmers and other elements. Design permits installation in upright instrument racks, with up to 10 channels in a single rack. Model Y4079 is a single channel, plug-in module using two C16J thyratons for a rated capacity of 40 amps in each channel. Overloads up to 200% of rating can be tolerated for up to 5 min. Modules available with individual cabinet enclosures. **Model G4078** uses ignitrons rated at 100 amps per channel.

For More Information
Circle EQ RSC #7

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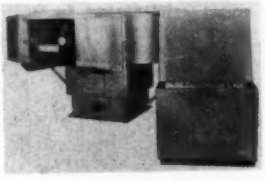
VARIABLE-SPEED ACCELERATORS

Models B-8-H and B-12-C, by **Schaevitz Machine Works,** permit radial acceleration testing of instruments, electronic components and electromechanical



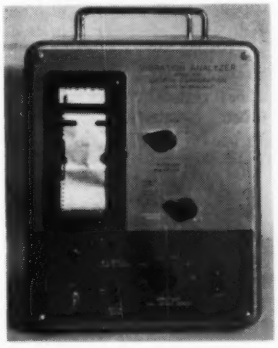
assemblies in range of 0 to 150 g. Features include low g-gradient, electronic speed control, digital rpm indicator, automatic dynamic braking, automatic reset, remote control console and steel safety guards. Operating noise level is said to be low. Current limiting provides controlled acceleration. **Model B-8-H** has 4-ft radius rotating arm which can mount 18-in objects weighing up to 100 lbs. **Model B-12-C** (illustrated) has 6-ft rotating arm for 24-in objects. Weight: 4,000 lbs and 6,720 lbs, respectively, plus 600-lb control console. Time-curve programming, closed-circuit TV, single or 4-line pressure or vacuum systems, temp conditioning and auxiliary rotating arms optional. Powered by 440 v, 60-cycle, 3-phase.

For More Information
Circle EQ RSC #8

* * *

RECORDING WAVE ANALYZER

Model 800, by **Optron Corporation,** measures and records on calibrated strip chart the amplitude of all freq components in any waveform from 20 to 20,000 cps. Applications include measurement of distortion, identification of sources of mechanical vibration, analysis of harmonic content and evaluation of sound systems. Outputs of accelerometers, microphones, strain-gages, pressure pickups



and similar transducers can be analyzed. Sensitivity is full scale from 15 mv to 6 v. Accuracy is 3% of measured freq and 5% of measured amplitude. Model 800 employs a variable filter whose bandwidth is a constant percentage of the freq to which it is tuned. Strip-chart is driven synchronously with filter. Unit becomes wide-band level meter if filter is switched out. Preamp is optional. Power required: 110/220 v, 50-60 cycles.

For More Information
Circle EQ RSC #9

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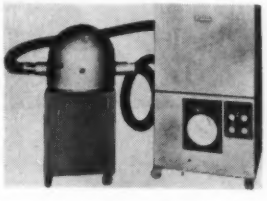
MOBILE TEMP CHAMBER FOR VIBRATION TESTS

Model W-2-100+200, by **Webber Manufacturing Co., Inc.,** has 19" insulated dome that fits



over test specimen. Temp range: —100° to +200°F, with pull-down over entire range in 45 min. Dome is connected to mobile chamber with two flexible, insulated hoses. Air is circulated to assure zero stratification. Unit is available with other temp ranges and hood styles and with air or water-cooled refrigeration systems.

For More Information
Circle EQ RSC #10

* * *

HI-TEMP, HI-PRESSURE ROTARY COMPRESSORS

Model HTP, by **Roots-Connersville Blower** division, **Dresser Industries, Inc.,** are single-stage units designed for 50 to 500

psig and operating temps up to 800°F. Inlet capacities from 500 to 5,000 cfm. Internal lubrication is not required. Steam-turbine, gas-turbine, or electric-motor drive is available. Open or closed-type impeller is mounted on a forged steel shaft supported by external pedestal bearings. Sealing systems include simple labyrinth, gas buffered labyrinth, dry or water-lubricated carbon ring, gas buffered carbon ring, mechanical face and liquid-buffered bushing-type seals.

For More Information
Circle EQ RSC #11

* * *

COMPACT, TOP-OPENING —130°F REFRIGERATOR

Model 2L-2-075, by **Harris Manufacturing Co., Inc.,** is designed to provide flexible service in metal treating, shrink

fitting or environmental testing in small shops or labs. Cascade refrigeration system is claimed to hold —130°F, ± 1°F. Features of the unit, which has capacity of 2 cu. ft., include protection against pressure build-up after power failure, automatic restarting, 2 cooling fans, rigid polyurethane foam insulation and 5-yr warranty on motor compressor. Also available is standard 10 cu. ft. refrigerator with cooling capacity of 1,000 to 5,000 BTU/hr at

—100°F and capable of holding —130°F.

For More Information
Circle EQ RSC #12

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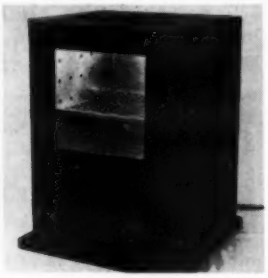
MINIATURE OZONE CHAMBER

Model MS (range: 25-700 pphm/vol) and **Model MSA**



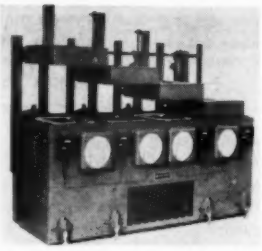
(range: .005% to .03%) by **Ozone Research & Equipment Corporation** incorporate all significant features of standard size ozone chambers. Have 1 cf capacity. Used in modest ozone programs or as overflow chamber.

For More Information
Circle EQ RSC #13

* * *

MULTIPLE-CHAMBER TEMP CABINET

Model SV-4-100-4-HC, by **Cincinnati Sub-Zero Products,** contains 4 chambers, each with



temp range of —100° to +400°F. Air-operated, vertical opening lids permit independent access to any chamber. Each lid can lift 100 lbs, so that additional equipment can be raised or lowered with test object. Chambers have individual indicating controllers and recorders. Blower assembly with 1,000-watt heater is provided for each chamber. Stainless steel interiors are 14" x 14" x 14". Lid assembly is 18" high; vertical rise of lid is 18". Overall exterior dimensions: 28" x 94" x 36" high. Weight: 2,000 lbs.

For More Information
Circle EQ RSC #14

* * *

ELECTRO-HUMIDITY TRANSDUCER

by **Phys-Chemical Research Corp.,** is wafer of chemically treated styrene copolymer with conducting surface layer integral with non-conducting substrate. Changes in rel hum cause electrical resistivity of surface to vary. A single transducer is said to be enough to cover entire rel hum range. Ohmic resistance varies from 40 megohms to 1000 ohms over the range. Requires ac voltage of at least 20 cps. Price: $8 to $12.50 each.

For More Information
Circle EQ RSC #15

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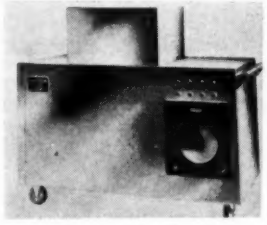
PRECISION-CONTROL LOW-TEMP CHAMBERS

Models 3005 and **3005A,** by **Cyro-Therm, Inc.** Model 3005 can be programmed to respond



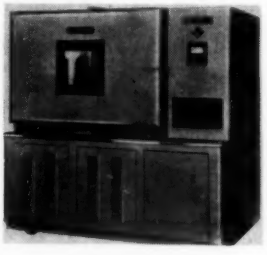
to rates up to 25°C/min from +20° to —200°C. **Model 3005A** can be programmed from +20° to —100°C. Applications include storage of live biologicals for indefinite periods and laboratory environmental testing. Cooling source is standard commercial nitrogen cylinder.

For More Information
Circle EQ RSC #16

* * *

CASCADE REFRIGERATED HI-LOW TEMP CHAMBERS

Series F, by **Bemco, Inc.,** feature Freon coolant and electric resistance-heating. Mild steel exteriors are finished in silver-gray hammertone; interiors are welded stainless steel. Insulation

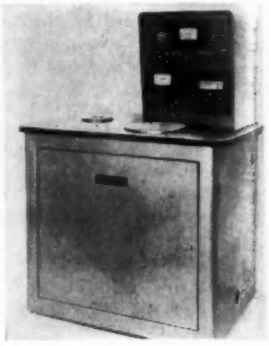


is glass fiber. Full-opening door, corrosion-resistant fan, casters and externally-mounted motor are furnished. Temp ranges are —100° to +350°F and —100° to +500°F. Available in 2, 3, 8, 27 and 64 cu. ft. Electronic control indicators, programming and recording instruments, door windows and interior lights optional. Prices start at $1,925, with instrumentation; 4-6 weeks delivery.

For More Information
Circle EQ RSC #17

2"-6" HIGH VACUUM PUMPING SYSTEMS

by **Tri-Metal Works, Inc.'s In-**



dustrial division evacuate bell jars for altitude simulation, vacuum ovens and other applications. Packaged system includes diffusion pump, liquid nitrogen trap and other features. Push-button operation.

For More Information
Circle EQ RSC #18

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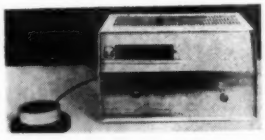
ULTRASONIC SHAKE TABLE

Model 160, by **Ultrasonic Industries, Inc.,** is said to be the first



of its kind for destructive and non-destructive testing of electronic and mechanical components, semiconductors and missile hardware. Freq range is 20 to 100 kc with a flat amplitude-of-motion curve. Accelerations of 4,000 g are claimed. Price: $750, fob.

For More Information
Circle EQ RSC #19

* * *

HIGH TEMPERATURE RESISTANCE TRANSDUCER

Model 2508, by **Winsco Instruments & Controls Co.,** uses platinum element to measure surface temps from 0° to +2,000°F. Installed with special high temp cement or welding. Measures are 1-9/16" x

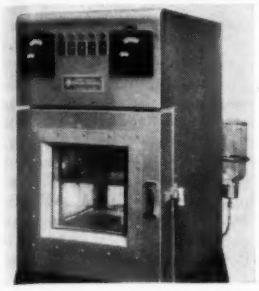
9/16" x .014" thick. Platinum element resistance is 100 ohms ± 1% at 77°F. Device meets or exceeds vibration and shock specs of MIL-E 5272C.

Guarantees QUALITY and SATISFACTION

ENVIRONMENTAL EQUIPMENT INSTITUTE
PRINCETON, NEW JERSEY

BENCH MODEL TEMP-HUMIDITY CHAMBER

Model SUB-Z-H by **Cincinnati Sub-Zero Products** provides 20 to 95% humidity as well as



temp ranges of —100° to +400° F. Available in 2, 4 and 8 cf sizes. Shown is illuminated stainless steel unit with 14" x 14" x 14" test area measuring 40" x 24" x 29" deep. Wet and dry bulb indicating controllers regulate conditions. Eight-inch air circulator, with fin coil evaporator, insures even temp. Door, hinged right or left, includes 12" x 12" frost-free, multi-pane window.

For More Information
Circle EQ RSC #21

* * *

ALTITUDE TEST CHAMBER

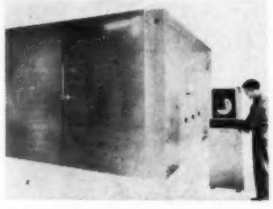
by **Industrial Refrigeration Co., Inc.,** provides ultimate altitude of 200,000' and —100° to +240°F temp range. Pull-down to —90°F requires 45 min, heat-up to +240°F, 15 min. Evacuation to 150,000' requires 30 min. Chamber is 20" x 20" x 20". Manometer is supplied.

For More Information
Circle EQ RSC #22

* * *

2100 CF WALK-IN TEMP-HUM CHAMBER

Model WF-2100-125+300H by **Webber Manufacturing Co.** provides temp range of +300° to —125° and 20 to 95% relative humidity for electronic and other applications. Has 15' x 20' x 7' high unobstructed interior

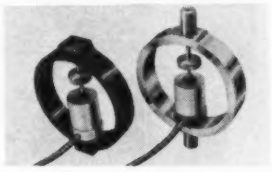


and features patented cascade, automatic defrost and thermal capacity of 56,000 BTUs, with less than 1° inside air stratification. Exterior: 16'4" x 22'2" x 8'4". Refrigeration units may be placed anywhere within 50' of cabinet. Separate console for programmed instrumentation. Frost-free viewing windows and ports.

For More Information
Circle EQ RSC #23

HIGH PRECISION LOAD CELL

Type BT-35, by **United Aero Products Corp.,** permits external



zero adjustment and easy access to all connections. Pressure ranges available up to 10,000 psi. Operating temp: —115° to +500° F. Case diam: 3½". Frictionless movement.

For More Information
Circle EQ RSC #24

* * *

CALIBRATION RETICLE ADAPTOR

by **Columbia Research Laboratories** permits direct visual calibration over 30 to 200 cps range. Hexagon-shaped device can be provided with standard-size studs or bores to fit thread sizes of usual shaker tables and accelerometers. Available reticle patterns are the CRL Wedge for measurement of 20, 40, 60 and 100 mils double amplitude and the CRL Para-Line, a series of parallel lines spaced .0647," for measurement of ±10G at 55 cps. Price: $20-$25, depending on quantity.

For More Information
Circle EQ RSC #25

COMPACT RADIATION MACHINES

by **Hughes Aircraft Company,** include desk-size monopulse and steady-state linear accelerators designed to produce high-intensity radiation in short pulses. Radiation intensity of the monopulse linac is 10 million roentgens per sec at 6 to 8 million electron-volts. Energy level in the steady-state linac is 4 to 12 million electron-volts.

For More Information
Circle EQ RSC #26

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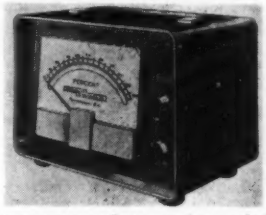
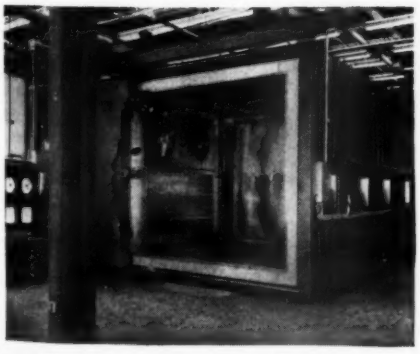
POWER SUPPLY AND READOUT UNIT

Model TCR-I, by **Schaevitz Engineering,** for general testing and stress analysis, supplies a dc voltage to pressure and force

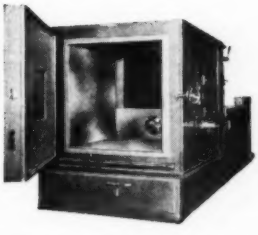


transducers that can be varied from 10 to 15 v, ± .1%. Rapid calibration and readout accuracy to .25% of full range is claimed. Unit contains 4-in scale and taut-band meter said to be 10 times as sensitive as conventional meters. Sensitivity

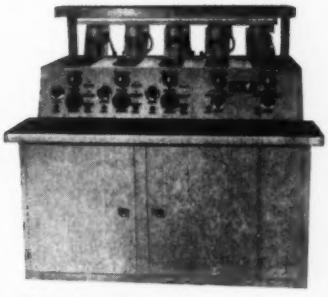
FOR SIMULATION YOU CAN RELY ON...
DEPEND ON AR★ BUILT-IN QUALITY



Altitude — Temperature — Humidity Walk-In chamber, with provision for mounting shaker inside test area. Also available without Altitude simulation.



Altitude chambers in any size — Altitude 200,000 ft. or higher; Temperature +500°F and higher to —100°F and lower; Relative Humidity simulation available.



Precision temperature calibration bath, completely self-contained, provides five separate temperature increments within a total range from — 100°F. to +500°F. with an accuracy control within ± 0.1° F.

Designers and manufacturers of Altitude, Temperature, Humidity, Sand & Dust, Rain & Sunshine, Explosion, Special Air and Liquid Chilling and other types of Environmental Test Equipment.

All size chambers available — Write for catalog.

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is full scale for any 120- to 350-ohm strain-gage transducer having output of .001 v/v; response time is 2 to 3 sec full scale. Model TCR-1 is 8" x 8" x 10" wide, weighs 7 lbs, requires 115 v, 60-cycle power.

For More Information
Circle EQ RSC #27

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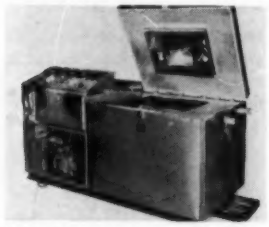
TEMPERATURE TEST UNIT ACCOMMODATES VIBRATION

Zerolab Model 2-300 by **Solar Systems, Inc.,** produces —320° to +400°F. Has front opening



for wiring, thermocouples or vibration testers. Chamber is 72" x40"x38" high, has observation window in counter-balanced hinged top, interior lighting and special bracket for liquid carbon dioxde or nitrogen assist cylinders. Caster mounted.

For More Information
Circle EQ RSC #28

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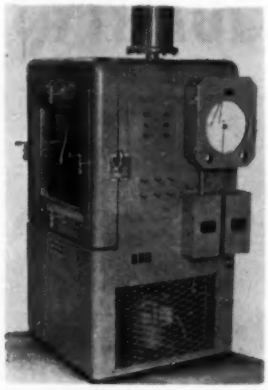
VAC/PRESSURE TEMP CHAMBER TO TEST PRESSURE DEVICES

Model ASU-40-3-HC, by **Cincinnati Sub-Zero Products,** is designed for testing and calibrating pressure-sensing and



pressure-indicating instruments. Pressure range is 20" to 32" Hg abs from —40° to +200°F. Cabinet has six ¼" stainless steel connectors and six Sealtron 30-amp terminals; in the door is a 20" x 20" multipane window. Stainless steel interior measures 20" x 20" x 12"; exterior is 32" x 32" x 64". Controller and electropneumatic interrupter are installed. Power is 230 v, 60-cycle, single phase.

For More Information
Circle EQ RSC #29

FAST-OPENING HI-PRESSURE VALVE

by **Research, Inc.,** developed to

produce an explosive air blast in an aircraft arresting device, may have application in rapid pressurization of pressure vessels, rapid pressure release and simulation of explosive phenomena. Actuated by solenoid, valve is fully open in 15 millisec after solenoid plunger starts moving. Max operating pressure is 1,500 psi. Orifice 3" in diam now being produced. Principle applicable to broad range of sizes and pressures.

For More Information
Circle EQ RSC #30

* * *

PORTABLE OZONE RECORDERS

New **O_3R Series** by **Ozone Research & Equipment Corporation** provides standard atmospheric or ozone test chamber ozone concentration measure-

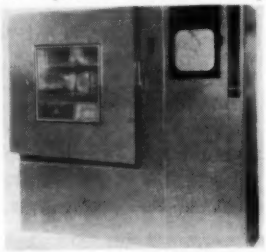
ment ranges as low as 0-15 and up to 0-120 pphm/vol. Instruments operate on continuous 3-day schedule. Accuracy 3% of operating scale. Weighs 31 lbs. Power, 95w, 110v ac. Available with battery-operated dc modification for field use.

For More Information
Circle EQ RSC #31

* * *

TEMP-HUMIDITY CHAMBER

Self-contained **Model TH-100,** by **Wyle Laboratories,** provides rel hum ranges of 20% to 95% ± 5% at dry bulb temps of 35 to 200°F, limited by 35°F dew point. Extended temp



ranges can be furnished to order. Steam generator and single-stage mechanical refrigeration for humidification and dehumidification, respectively; heating is by electrical resistance. Requires only 5-gal distilled-water bottle. Standard sizes are 8, 27 and 64 cu. ft. Requires 110 v, 60-cycle, single phase current.

For More Information
Circle EQ RSC #32

* * *

DRAWER OVEN

by **Blue M Electric Company** permits concentrating workload in one location for simultaneous processing of thousands of small

parts of steel, rubber or plastic. Temp ranges of 100° to 356° F and 100° to 600° F for aging, drying, preheating, curing and baking. Drawer dimensions: 18½" x 20" x 5" high. Features include 50 air changes a minute, horizontal airflow, and Blue M's Power-O-Matic 60, saturable power reactor control and range-lock protection.

For More Information
Circle EQ RSC #33

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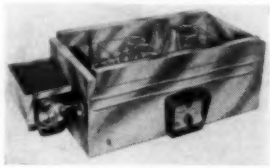
GENERAL-PURPOSE LAB SHAKING BATH

Model 61, by **Labline, Inc.,** is designed to provide continuous agitation up to 400 oscillations/min and /or temp control from



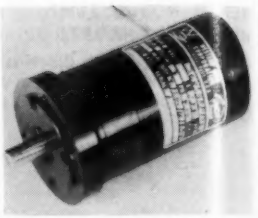
0° to 100° C, ±.5° C. Stroke gradations vary up to 2½" Drive is ⅛ hp, constant-speed, induction-type motor with integral speed reducer. Drive shaft has nylon bearings. Universal-type stainless steel tray is 9" x 19" long. Bath is 18-8 stainless steel. Insulation is 1" air cell. Ice basket or cooling coils are available for operation below room temp.

For More Information
Circle EQ RSC #34

* * *

MOTOR WITH INTEGRAL GEARHEAD

Model 36V58RP138, by **Electro Products Division of Western Gear Corporation,** is used as safety rod drive in nuclear radiation environment. Output is 20 oz-in. torque at 333 rpm continuous duty. Operating life is



1000 hrs. Precision II gearbox has max 1° backlash under 150 oz-in. torque. Motor is reversible and is designed to operate in water-saturated helium atmosphere at 50° to 95° C. Diam, 1½". Length, excluding shaft extension, 2¾". Weight, 14 oz. Power input is 115v, 400 cycle, 3 phase.

For More Information
Circle EQ RSC #35

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LABORATORY AC POWER REGULATORS

by **Research, Inc.,** use silicon-controlled rectifiers to regulate power levels up to 4.6 kw. Devices, tradenamed **LabAC,** permit manual or automatic control up to 230 v. Output is

infinitely variable from zero to full power in response to 0 to 5 ma control signal. Four models have current ratings of 10 or 20 amps and voltage ratings of 115 or 115/230 v. Applications include regulation of power to lab apparatus, electric furnaces, and replacement for power relays and mechanical contactors in on-off power control. Weight: 7½ lbs.

For More Information
Circle EQ RSC #36

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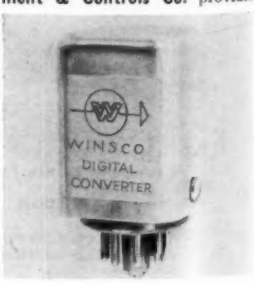
SOLID-STATE DIGITAL CONVERTER

Model 4310, by **Winsco Instrument & Controls Co.** provides



for direct digital measurement of temp, pressure and other process variables. In high-vacuum, space-simulation chamber, device converts output of resistance temp transducer into variable freq which can be transmitted without wires through chamber wall to digital freq-period counter. Counter can be calibrated for direct temp display or for recording on printer. Input: 500 to 3,000 ohms. Available freq ranges, 400 cps to 70 kc; full range output freq deviation, 7.5% at 5 VAC. Conversion linearity: +1% at 7.5% freq deviation. Weighs 4 oz. Price: $159.

For More Information
Circle EQ RSC #37

* * *

CHILLER FOR TESTING AUTO ELECTRICAL PARTS

by **Cincinnati Sub-Zero Products,** can provide low temp of —80°F, ± 1°F, with a capacity of 1,000 BTU/hr. Stainless steel chamber is 20" x 20" x 20" and is equipped with 1" diam ports, 50-amp terminals, chamber light and 12" x 24" multipane, frost-free window.

For More Information
Circle EQ RSC #38

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PIEZOELECTRIC ACCELEROMETER

Type EM 900, by **Raytheon Company,** is designed to eliminate distortion resulting from mounting and disturbance resulting from connecting cable motion. Shocks up to 10,000 G's are said to produce no measurable hysteresis. Sensitivity is 15 mv/G; capacitance without cable: 1100 mmf. Temp range: —100° to +500°F. Freq response: 1 to 10,000 cps. Sensitivity loss at 250°F about 5%; at 500°F about 40%. Weight: 35 gm. Price: $128-$145, depending on quantity.

For More Information
Circle EQ RSC #39

* * *

AUTOMATIC-CONTROL SALT-SPRAY CHAMBER

Model S-102, by **Wyle Laboratories,** meets specs of MIL-E-5272C, 202A, and federal test method Standard 151. Heated water reservoir, pressure regulator, plumbing and electrical

system are compartmented at right side of chamber, and heater and thermostat susceptible to corrosion are eliminated from salt-solution reservoir. Operating temp: 35°C. Sealed fiberglass-resin test compartment is 32" x 21" x 24" deep.

For More Information
Circle EQ RSC #40

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SPECIAL-PURPOSE CHILLING UNIT

Model B-10, by **Cincinnati Sub-Zero Products,** is designed to operate at holding temp of —40° F to retard age-hardening of aluminum rivets and blanks. Caster-mounted unit contains 5 removable racks. Capacity is 50 cannisters 2" diam x 10" long. Manually regulated temp from +20° to —40° F, is said to be maintained for 1½ hrs with

current off. Chamber is 26" x 18" x 20" deep, exterior 32" x 24" x 46" high.

For More Information
Circle EQ RSC #41

* * *

ULTRA-MINIATURE TEMP TRANSDUCER

by **Winsco Instruments & Controls Co.** has time response of 20 millisec or less with tungsten element. Element diam: .100"; sensitive length: .35". Pressure rating: 6,000 psi (max). Designed to meet vibration and shock specs of MIL-E-5272C. Weight under 1 oz.

For More Information
Circle EQ RSC #42

Government Publications

Almost daily the U. S. Department of Commerce releases a number of technical reports for use by industry. These documents are sold through the department's Office of Technical Services, Washington 25, D. C. Here are some recent releases and their prices:

(NOL—Naval Ordnance Laboratory)
(ONR—Office of Naval Research)
(WADC—Wright Air Development Center)
(WADD—Wright Air Development Div.)

Series of Russian aeronautical science translations: The First Flight to the Moon, Priroda, USSR, 12 pages, order No. 60-31250, 50 cents; *Shock Waves in Solids,* L. P. Orlenko and K. P. Stanyukovich, Izvestiya Vusshikj Uchebnykh Zavedeniy, 17 pages, order No. 60-11913, 50 cents; *High-Power High-Frequency Test Stand for Endurance and Vibration Strength of Jet Engines and Aviation Materials* at the Moscow Aviation Institute and the All-Union Institute of Aviation Materials, 19 pages. Order No. 60-41053, 50 cents.

Role of Structural Damping in Acoustical Fatigue, by W. J. Trapp, Materials Laboratory, and B. J. Lazan, University of Minnesota, for WADD. Fatigue mechanisms and significant parameters are analyzed in proposed noise damping techniques for high acoustic-level aircraft powerplants. 31 pages. Order No. PB 161742, $1.

Electronic Designer's Shock and Vibration Guide for Airborne Applications, by R. E. Barbiere and W. Hall, RCA Service Company, for WADC. Discusses theoretical and practical aspects of shock and vibration on airborne electronic equipment. Techniques of resisting or changing the environment are discussed. 260 pages. Order No. PB 161299, $4.

Study of Ultra High Temperatures, by A. V. Grosse and C. S. Stokes, Research Institute, Temple University, for WADC. Final report of four-year study of chemical and physical phenomena up to 5000° K. 26 pages. Order No. PB 161460.

Human Engineering Bibliography 1957-1958, by Tufts University for ONR. Human engineering literature in 490 periodicals as well as government, industrial and academic laboratory publications. 235 pages. Order No. PB 161125, $5.

Human Engineering in the Navy—1959, by P. G. Cheatham, Engineering Psychology Branch, ONR. Summarizes human engineering progress in the Navy and recommends improvements. 14 pages. Order No. PB 161428, 50 cents.

Selective bibliographies from Government research reports and other technical documents: Corrosion (10-year bibliography). Order No. SB-401, 10 cents. *Reliability and Quality Control* (1950-1960). Order No. SB-405, 10 cents.

Damping of Rectangular Plate Vibrations, by T. S. Lundgren and others, University of Minnesota, for WADD. Analysis of two similar vibration damping devices as part of an Air Force investigation of metal fatigue due to jet noise. 25 pages. Order No. PB 161755, 75 cents.

On the Utilization of the Concept of Boundary Impedance in Vibrations of Bars, by F. J. Wilmers and R. F. Lambert, University of Minnesota, for WADD. Use of the concept at the extreme boundaries of a bar and its measurement by electrical transmission line theory. 44 pages. Order No. PB 161740, $1.25.

A Piezoelectric Force Gage for Measuring Drag on Two-Dimensional Models in the Shock Tube (U), by W. G. Zuke and L. W. Slifer, Jr., NOL. Discusses design and sensitivity of gage developed during study of drag forces produced by shock waves. 61 pages. Order No. PB 161872, $1.75.

The Response of Mechanical Systems to Random Vibration as Determined by Analog Computer, by V. C. McIntosh, Aeronautical Accessories Laboratory, WADD. Responses of linear two-degrees-of-freedom systems and non-linear one-degree-of-freedom systems to both sinusoidal and random vibration are analyzed. Study was made to gain basic information on the relative merits of the two types of testing. 38 pages. Order No. PB 161794, $1.25.

ENVIRONMENTAL BUSINESS...

ATL Doubling Size of Its New Wayne Plant; CVC Allots $500,000 for General Expansion

ON THE DOTTED LINE will grow 32,000 square feet of production and testing space at Associated Testing's headquarters plant in Wayne, N. J.

Associated Testing Laboratories, Inc., is planning to more than double the area of its headquarters plant, opened only a year and a half ago, in Wayne, N. J. The additional space, totalling 32,000 square feet, will be shared by the firms' Testing and Manufacturing divisions, according to William Tonkowich, president.

New vibration and altitude-simulation systems will be installed by the Testing division. The Manufacturing division anticipates improved efficiency in production of the new Econ-O-Line series of temperature-humidity chambers, which start at $285.

ATL, meanwhile, reported a 280 per cent rise in net income on a 100 per cent increase in sales during fiscal '60. For the year ended May 31 last, volume reached $2,051,647, Bernard Novack, chairman, reported, compared with $1,070,948 the year before, and profits after taxes were $228,969, or 50 cents a share, compared with $60,670. Novack told stockholders the current year's sales goal is $4 million.

In its first '61-'62 quarter, ended Aug. 31, ATL reported sales of $571,000, up from $240,000 the year before, and net income of $50,000, a tenfold increase.

Growth of Vacuum

In Rochester, N. Y., Consolidated Vacuum Corporation, a subsidiary of Consolidated Electrodynamics/Bell & Howell, announced a half-million-dollar expansion program to provide additional manufacturing, research and service facilities.

Malvern J. Gross, vice president-manufacturing, said production capabilities would be increased 33 per cent. Construction of a 23,000-square foot plant addition is due to be completed next April.

Guido Ruggiero, CVC's treasurer, said this was the beginning of a long-range expansion program stemming from "growth of vacuum in industry, the role that CVC is playing in space age exploration and vacuum metallurgy." He said CVC has doubled its sales and earnings in the last two years "and forecasts seem to indicate the trend will remain."

Schaevitz Service Teams

Schaevitz Machine Works, Pennsauken, N. J., is sending inspection-service teams to all customers using Schaevitz rotary accelerators. There is no charge to the customer for the service. All the equipment is sold under a lifetime guarantee.

Endevco Sets Up Solid State Research Lab

Endevco Corporation, Pasadena, Calif., has established a solid state research laboratory at Los Altos, Calif., with Lewis E. Hollander, Jr., as director. The facility, Endevco's eighth since 1949, will conduct basic research into the performance and characteristics of solid state materials for instrumentation.

"Future measuring instruments," Wilson Bradley, Jr., executive vice president, said, "will utilize electrical phenomena associated with unusual solid state or crystalline materials."

He said piezoelectric transducers were examples of the sensitivity and environmental advantages these materials have over other measuring methods.

Hollander has been with Lockheed's Missile and Space division, the Atomic Energy division of American Standard, Industrial Nucleonics and Victoreen Instrument.

Bethlehem Acquires IRC

The Environmental Engineering division of the Bethlehem Corporation, Bethlehem, Pa., has acquired the assets of International Radiant Corp., New York environmental equipment manufacturer. A. A. Sickler, executive vice president of Bethlehem, formerly Bethlehem Foundry and Machine Co., said key IRC personnel have joined his company.

Test Labs Install New Facilities

Widening demand for environmental testing and increasingly stringent requirements are reflected in new facilities of the commercial laboratories.

A blast shock test machine developed by Wyle Laboratories, El Segundo, Calif., is designed to provide simultaneous horizontal and vertical shock forces on specimens weighing up to 6,300 pounds. The machine simulates a Titan II hard-site isolated platform for ground support equipment.

Wyle has also installed a Ling Electronics' Model L-200 vibration exciter to obtain 100 gs on a 100-pound test specimen or 60 gs on a 250-pound specimen. Rated at 22,000 force-pounds, it is powered by a 120 kw amplifier. The design of the exciter armature, which weighs 115 pounds, is said to be unique.

In operation at Wyle's Parameters Division, Westbury, N. Y., is a system composed of a 50 kw Ling amplifier, Model PP 50/70, a Ling spectral density equalizer/analyzer, Model ESD-20/ASD-20, and a Ling vibration exciter, Model A246, rated at 7500 force-pounds.

Rototest Widens Capabilities Elects Pilnick General Manager

Expanded capability for shock, vibration, high vacuum and instrumentation testing was announced by Rototest Laboratories, Inc., Lynwood, Calif., as Carl Pilnick, formerly of Consolidated Avionics Corp., was elected executive vice president and general manager.

Rototest's new shock facility consists of a Barry Varipulse Model 15575, producing half-sine pulses from 2 to 65

Ling's new L-200 shaker with its unique exciter armature is shown on the floor of Wyle Laboratories, El Segundo, Calif. (For more info circle EQ RSC "H.")

milliseconds and requiring 6.5 milliseconds to attain 100 g with a 100-pound load. Vibration testing has been enlarged with a Ling Model 275, which can produce 10,000 force-pounds.

New high vacuum equipment includes an NRC six-inch diffusion pump with an ultimate capacity of 10^{-6} mm Hg.

Aerotest Offers New Bi-Propellant Tests

Aerotest Laboratories, Inc., Deer Park, N. Y., has installed a facility to test reliability and compatibility of missile components, materials and systems with bi-propellants such as nitrogen tetroxide, UDMH and hydrazine, H. J. Shapiro, president, announced. **(For more info circle EQ RSC "L.")**

News of Other Labs

New York Testing Laboratories, Inc., New York, N. Y., has acquired a 50-foot vessel to serve as a floating marine laboratory for testing marine electronic items, corrosion protection devices and de-salting processes. The project is a joint venture with Whitehead Brass Foundry, Inc.

Wyle Laboratories, El Segundo, Calif., will establish an aerospace testing laboratory in Huntsville, Ala., to provide standards, calibration and environmental simulation services. Frank S. Wyle, president, said the laboratory is scheduled to be in operation early next year. A field engineering office has already been opened with Cecil Fiquett in charge.

United States Testing Company, Inc., is opening a new branch in Chicago this month to serve as a sales office and psychometrics testing station initially, and a physical testing laboratory in the future. It is located in the Board of Trade building. The main U. S. Testing lab is in Hoboken, N. J.

Genarco Simulator to Bell Labs

Genarco, Inc., Jamaica, N. Y., has produced a high-intensity carbon arc solar simulator to irradiate a 40-inch space vehicle at Bell Telephone Laboratories. Radiation is of the same spectrum and intensity as the sun in the outer atmosphere.

Ling Builds 'Artemis' Amplifier

A "very large" water cooled sonar amplifier, unique for its type, has been designed and built by Ling Electronics division of Ling-Temco-Vought, Inc., for Project Artemis, Cameron G. Pierce, president of Ling, disclosed. The amplifier will power a sonar transducer that is five stories high and weighs hundreds of tons. On board a modified Navy tanker, it will help determine the feasibility of long-range tracking of submarines.

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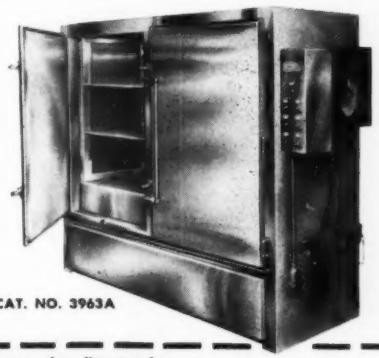

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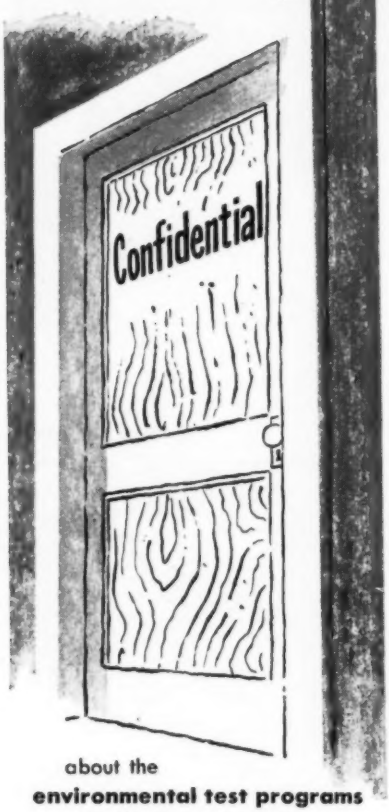

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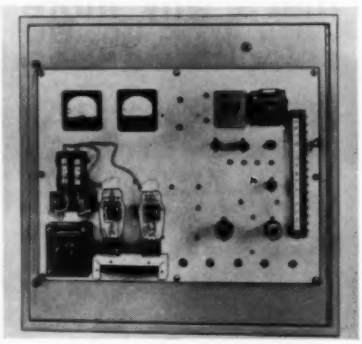


Electronic control regulator in power control package of Tenney Engineering's new line of variable speed drives eliminates need for motor generator sets without sacrificing regulation or drift characteristics. (For more info circle EQ RSC "I.")

Tenney Engineering, Inc., Union, N. J., has entered the field of industrial process controls with a line of variable speed drives, first developed to control the spin of a satellite in an orbital simulator.

The power control package of the drives incorporates an electronic regulator said to eliminate the need for a motor generator set without sacrificing regulation or drift characteristics. Standard drives offer .5 to 2% regulation of set speed. Custom drives are available with regulation as precise as .1%. Remote controls are available.

Pulsed X-Ray System

A pulsed X-ray system, a novel means of studying vibration and shock tests, is being marketed by MB Electronics, New Haven, Conn. The system was developed by Zenith Radio Research Corporation.

Key feature of the system is its relatively cool X-ray tube target, which permits an increase in energy per pulse sufficient to penetrate test specimens and produce satisfactory film density. The low temperature of the tube target is achieved by shutting off the X-ray source between exposures. Capacity is 30 pulses per second.

"Through the use of pulsed X-rays, the nature of hidden component performance and failure under test can be probed to an extent never before possible," Galt B. Booth, technical director of MB, said. **(For more info circle EQ RSC "J.")**

Cold Vacuum Baffles

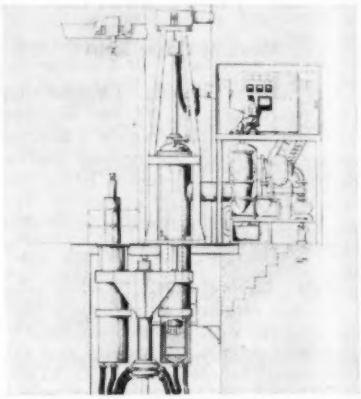
NRC Equipment Corporation, Newton, Mass., is introducing a line of vacuum system baffle cold traps featuring a circular chevron design and a centrally-located coolant reservoir. The traps are said to be "optically opaque," in that gas or pumping-vapor molecules, which travel in straight lines at high vacuums, cannot pass through the assembly without striking a baffle surface.

The new NRC traps can be cooled by agents commonly used in vacuum systems, such as water, liquid nitrogen, or mechanical refrigerators. Designed with full-flow cross-sections in each size, the units can be used in ultra-high vacuum systems operating to the 10^{-10} mm Hg range. **(For more info circle EQ RSC "L.")**

Unique Vacuum Furnace

Consolidated Vacuum Corporation, Rochester, N. Y., will install a vacuum arc furnace said to be the first of its kind in this country, at Special Metals, Inc., New Hartford, N. Y. The contract is for $500,000.

Unique feature of the furnace is ingot removal by rotation of the crucible



Artist's drawing of CVC's unique vacuum arc furnace, which will feature lazy Susan design.

and simultaneous positioning of a new crucible. The furnace will be used to arc remelt both air-melted alloys and vacuum - induction - melted alloys. A CVC pumping system will evacuate the remelt chamber. **(For more info circle EQ RSC "K.")**

Chamber for Douglas

Cincinnati Sub-Zero Products has built this 64-cubic foot aircraft parts tester for Douglas Aircraft Co., Inc. Specs: −100°F in 2½ hrs.; +200°F in 1 hr.; 100,000' in ½-hr.; 20% to 95% hum (DP limitation of 35°F). For more info circle EQ RSC "G."

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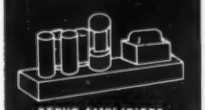
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DePoy Named by Harris

Stewart M. DePoy, a pioneer advocate of cold treatment for steel, has been named regional representative for low temperature equipment of Harris Manufacturing Co., Inc., Cambridge, Mass., for Michigan, Ohio and western Pennsylvania. His headquarters will be at 1179 Piermont Rd., Cleveland 21.

High Vacuum Promotes White

William B. White has been promoted from sales administrator to vice president, administration, of Vacuum Equipment Corporation, Hingham, Mass., subsidiary of Robinson Technical Products, Inc. The company specializes in high vacuum simulators and furnaces.

On the Selling Side

Jesse Markson's E. R. A. Inc., engineering representatives, has completed construction of its new offices in Great Neck, N. Y. New members of the field engineering staff include Stuart J. Cohen, Michael Trubowitsch, Joseph Ligori and Jerry Gold.

Varian Associates' Vacuum Products division has opened a district office in Cleveland (25000 Euclid Ave., Euclid 17) under the direction of Arthur Shivers. It covers Ohio, Michigan, western Pennsylvania and western New York.

Maher Engineering Co., Chicago, and **W. A. Brown & Associates**, with offices in the Southeast, have been named representatives of Strong Electric Corp. for the Jetarc solar radiation simulator.

Roots-Connersville Blower, division of Dresser Industries, Inc., has opened a branch office in Midland, Texas. LeRoy C. Laycock has moved over from Houston to take charge.

Lazarus a Consultant

Maxwell Lazarus, former project manager at Barry Controls, has become an independent consultant in the field of shock and vibration. His shingle is hanging at 1197 Beacon St., Brookline, Mass. A graduate of Northeastern University and a registered professional engineer in Massachusetts, he joined Barry after several years with the Navy and rose to positions in which he was in charge of all long range projects involving special shock machines, large isolation systems and special damping devices, and then all engineering quotations and proposals.